SOIL SURVEY IN THE SEVIER VALLEY, UTAH.

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INTRODUCTION.

The area surveyed, about 220 square miles, is located just south of the center of Utah, in the counties of Sevier and Sanpete. It begins at the town of Joseph, where the valley is quite narrow, and extends in a general northeasterly direction for 45 miles to the town of Gunnison, where the valley attains its maximum width. This portion of the valley, having an average width of 5 miles, is bounded on both the east and west by prominent mountain ranges which rise quite abruptly from the usually level floor of the valley. The altitude of the valley varies from 5,300 feet at Joseph to about 5,000 feet at Gunnison, while the adjacent mountains rise from 2,000 to 6,000 feet higher. South from Joseph the valley is quite narrow and there is very little land suitable for agriculture. North from Gunnison the valley maintains a width of two or more miles for some distance, but the land is so salty and the water supply so scanty and poor that very little has been done there agriculturally. (Fig. 20.)

At Gunnison the Sevier River is joined by the San Pitch River, and northeast of Gunnison is situated the San Pitch Valley, in which are a number of prosperous towns and a considerable area of good farming land.

The adjacent mountain ranges running parallel with the valley are cut in many places by canyons, more or less prominent, through which enter small streams, some of which are perennial and others intermittent. The perennial streams are all on the east side, and in the aggregate they furnish sufficient water to irrigate several thousand acres of land. All of the streams on the west side are dry for the greater part of the year, but in times of freshets they become veritable mountain torrents.

These canyons, with their freshly eroded and precipitous sides, are exceedingly interesting and furnish excellent opportunity for geologic study. Vast beds of rock salt, networks of pure gypsum, and sedimentary lime and sandstones, with myriads of imbedded marine shells, all tell a story of a former geologic age when these mountains were submerged beneath the sea. Here is told in nature's language, which needs no embellishment, the story of mighty eruptions that took place in past ages. Lava flows, igneous rocks, and faults that

are measured by thousands of feet expose rocks and formations of almost every known geologic age.

Although this portion of the Sevier Valley is supposed to be above the Bonneville beds, yet the elevation at Gunnison and vicinity is such that it is not impossible that the water of that ancient lake when

FIG. 20.—Sketch map of Utah, showing areas surveyed.

at its highest stage may have reached into this portion of the valley. There is good evidence of shore lines low down on the base of the mountains in this vicinity, which, however, may have been formed by a local lake.

The Joseph district was undoubtedly a small lake, caused by a dam across the valley at its narrowest place between Joseph and Elsinore. Dams of this kind are known to be common and are caused by the débris brought down by a side stream, which is deposited in the bed of the larger stream, thus causing a lake to occur back of it.

The adjacent mountains abound in all kinds of mineral wealth. Gypsum, salt, alum, coal, lead, copper, and gold are all known to exist in workable amounts, but as yet the mining industry has been but little developed. At Sterling, 6 miles northeast of Gunnison, coal is being successfully mined; and to the south of Elsinore are several gold mines that are being successfully operated. In the vicinity of Salina are extensive beds of rock salt of remarkable purity, which as yet are utilized only for stock salt and to some extent for the home demands. With cheap transportation this material could be profitably put on the market.

The Monroe Hot Springs, just north of the town of that name, are worthy of notice. If they were on the outskirts of one of our chief cities they would be worth a large fortune. From these springs flow about 200 gallons of water per minute, the water having a mean temperature of 150° F., and being mildly charged with salts, especially salts of lime, magnesia, potash, and soda. A small bath house is constructed there which is patronized by the people of the neighborhood. The water is said to have effected some remarkable cures, and is certainly pleasant to bathe in. At a very moderate expense the water of these springs could be piped into the houses of Monroe and utilized for baths, and perhaps for heating and other purposes. On another page is given the analysis of this water for irrigation purposes.

In the larger mountain passes a considerable growth of pine which furnishes good timber is found. On the higher mountains the winter's snow lingers during the greater part of the summer, and, together with numerous springs, furnishes a limited supply of water through the summer. This constant water supply, entering the valley by way of small canyons, affords excellent opportunity for developing water power. From this source could be generated sufficient electricity to furnish light and power for all the towns in the valley. Electric lights, city waterworks, and telephones are conveniences which enterprising towns throughout the West generally have, and these improvements greatly add to the comfort and convenience of any community. The towns of the Sevier Valley can obtain these improvements cheaply, and they will prove good investments.

Until recently the railroad facilities of the valley have been very poor, but the Rio Grande Western has now extended its line to Marysville, and will push still farther south. This affords an outlet for the products of the valley, furnishes a means of getting provisions from other localities, and brings the people into closer relation with other parts of the country.

The mountains and plateaus adjacent furnish summer range for thousand of sheep, which during the winter are brought into the valleys and fed with the crops of alfalfa and grain.

Monthly and annual precipitation from 1897 to 1900, also the mean for ten years record, Richfield, Utah.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
1897	1.00	1.85	1.95	0.12	0.06	0	0.04	0.25	1.45	1.59	......	0.40	8.71
1898	.70	:30	.40	.15	1.20	1	.40	.35	0	0	0	Tr.	4.50
1899	.30	.55	4.65	.70	Tr.	.14	.16	.12	.07	.38	.20	1.05	8.32
1900	.45	.20	0	.60	.C8	Tr.	0	.07	.07	.05	.30	0	1.82
Mean for 10 years	.76	.91	1.64	.78	.38	.41	.49	.86	.66	.51	.16	.88	8.44

The climate is distinctly arid, the annual rainfall at Richfield being only 8.44 inches, as shown by the mean of ten years' record kept by

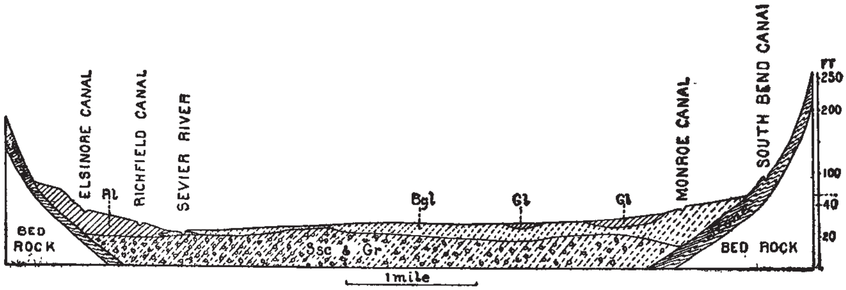


FIG. 21.—Profile of valley at Elsinore, Utah: *Rl*, Redfield loam; *Bgl*, Bingham gravelly loam; *Gl*, Glenwood loam; *Ssc & Gr*, Sandy loam and gravel.

the United States Weather Service. Since March, 1899, the precipitation has been unusually low. From that date to the close of 1900, a period of twenty-one months, it was only 4.64 inches.

The present soil survey was made during June, July, and August, 1900, by the Division of Soils, in cooperation with the Utah Agricultural Experiment Station.

All principal canals have been mapped and their waters examined with reference to their quality for irrigation purposes. Water was examined from the river, artesian wells, surface wells, and springs, and fully 60 analyses were made, the results of which are found in this report. Cross sections of the valley at Elsinore, Richfield, Salina, and Gunnison, showing the topography and soil section across the valley for these four places, are given in figs. 21 to 24.

In general the valley is level, there being a fall of about 7 feet per mile in the direction of the river and a fall from the base of the mountains to the river which usually does not exceed this, but at the mouth of inflowing streams the valley attains a maximum slope of about 100 feet per mile.

Sevier Valley near Richfield, native Vegetation Shad Scale.

The soils, usually light in texture, are formed largely from the adjacent mountains, although in certain level areas along the present river channel are deposits of material brought down from far up the valley. Owing to their mode of formation the soils are very diversified in character. At Joseph, Elsinore, and Monroe the soils are formed largely from igneous and lava rocks, and are consequently dark in color, while at Richfield the red sandstone gives rise to a soil of similar texture but almost vermilion in color.

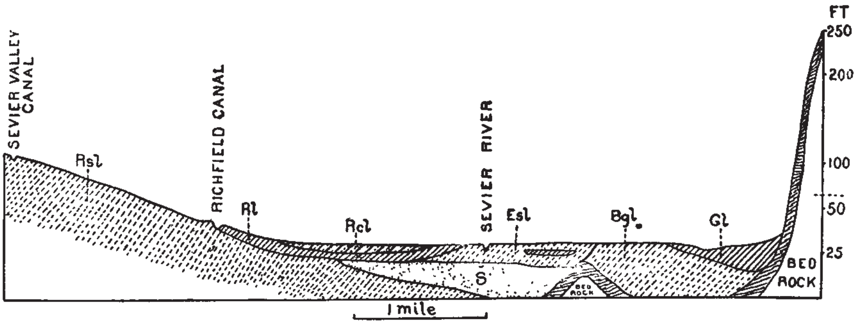


FIG. 22.—Profile of valley at Richfield, Utah: *Rsl*, Redfield sandy loam; *Rl*, Redfield loam; *Rcl*, Redfield clay loam; *Esl*, Elsinore sandy loam; *Bgl*, Bingham gravelly loam without gravel at this place; *Gl*, Glenwood loam.

About Joseph, Elsinore, and Monroe the soils are underlain by well-rounded, coarse river gravel, which continues for several hundred feet in depth, with occasional intervening strata of finer material or clay. In the river bed and over certain adjacent areas this gravel comes directly to the surface. It extends well toward the foothills, but is there covered by a much greater depth of soil. As we go northward

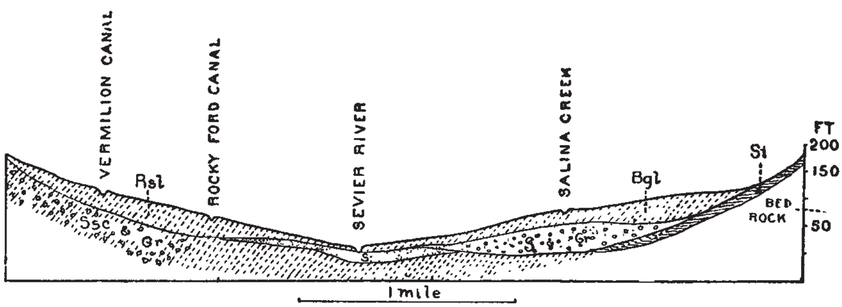


FIG. 23.—Profile of valley at Salina, Utah: *Rsl*, Richfield sandy loam; *Bgl*, Bingham gravelly loam without gravel at this place; *S*, sand; *S & Gr*, sand and gravel; *St*, stone.

along the valley this gravel becomes smaller and is found at a greater depth beneath the surface. At Elsinore the river bed takes water very rapidly, while east of Richfield seepage returns to the river in considerable quantity, and there is a large area of wet land in the vicinity. There are also large springs at the base of the mountains to the east, and it is not improbable that the source of much of this water is that which sinks in the river bed from Elsinore south.

The soils in the vicinity of Centerfield, like those at Elsinore, are underlain by river gravel to a great depth, the source of the material being from the San Pitch River.

The flora of the valley consists chiefly of greasewood, shad scale, rabbit bush, salt grass, foxtail, and a few other salt-loving species of annual plants. Sage bushes occur on the foothills and mountains, but are rarely found in the valley, owing to the usually salty condition of the virgin soils. The character of the vegetation bears an intimate relation to the kind of soil and to its condition, and a knowledge of this relation is of great assistance to the soil expert in mapping both soils and alkali.

Salt grass and foxtail indicate plenty of moisture at the surface of

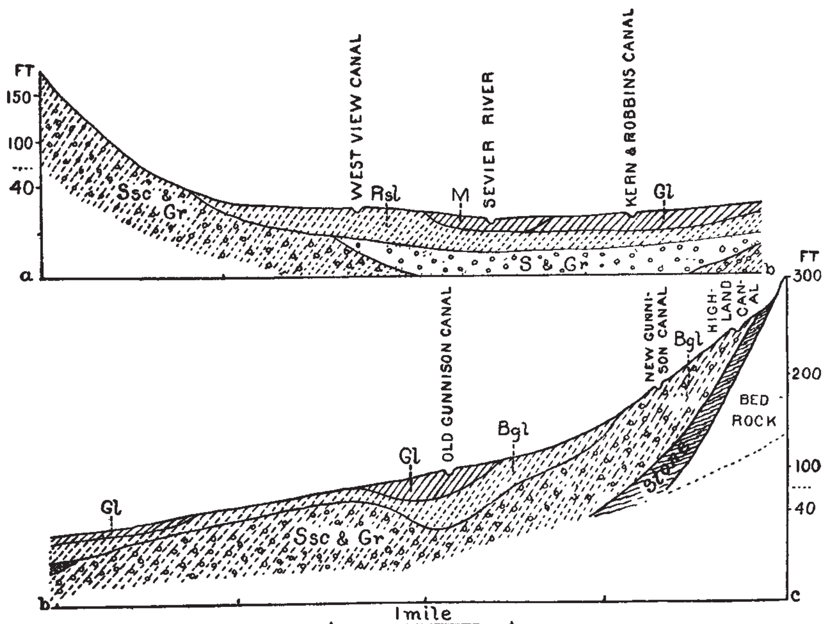


FIG. 24.—Profile of valley at Gunnison, Utah: *Ssc & Gr*, Mountain slope; *Rsl*, Reufiel l sandy loam; *M*, Meadow; *Gl*, Glenwood loam; *Bgl*, Bingham gravelly loam.

the ground, and consequently the presence of free ground water not far below the surface; while the salt grass indicates the presence of considerable salt, especially at or near the ground surface. Either of these plants is found on any type of soil. Greasewood indicates dry land of medium texture, containing considerable salt.

A heavy growth of greasewood, to the exclusion of other plants, indicates 0.6 per cent or more of salt in the upper 5 feet of soil. If the growth of greasewood is less flourishing, partly giving way to shad scale, the salt content will most likely be from 0.4 to 0.6 per cent. Shad scale alone indicates dry land with less than 0.4 per cent of salt and oftentimes less than 0.2 per cent. Rabbit bush flourishes best on

very sandy soils that are comparatively free from salts, and it will be seldom found to any extent under any other conditions. Sweet clover and foxtail, in fields of alfalfa or grain which have a poor stand, indicate wet land and probably from 0.2 to 0.4 per cent of salts. Bare spots in fields of grain or alfalfa indicate alkali, usually 0.2 per cent or slightly more for the general average of the field, but much more than this on the spots.

As a rule, the virgin soils of the valley are salty, owing to the fact that the salts are formed faster by the rapid disintegration of rocks than they are carried away by the scanty rains. In the vicinity of Joseph, Elsinore, Monroe, and Central the underlying gravel affords such good natural drainage that when these lands are placed under irrigation the salts are soon carried deep into the soil, where they can do no harm to the plants, and from whence they eventually find their way to the river in the seepage waters. Where the drainage is poor it is difficult to bring these lands into a condition of profitable cultivation without resorting to underdrainage. Fortunately the larger part of the lands of the Sevier are naturally well underdrained. Between Richfield and Glenwood there is a considerable area that needs drainage before it can be profitably reclaimed and cultivated.

The salt map, as constructed, shows the alkali conditions at the time of its construction, June to August, 1900; but a few years hence the conditions may be considerably changed through bringing virgin lands under irrigation, and thus washing the salts out; in other places the salts may be actually increased through the accumulation of seepage waters.

HISTORY OF IRRIGATION.

The first settlers entered the Sevier Valley in the early sixties. They were at first very much annoyed by the Indians, and in some instances were driven from their homes by them. A few small canals were in use previous to 1870, but it was from 1870 to 1880 that most of the important canals were constructed. The South Bend and Sevier Valley canals, as well as several others, have been constructed since 1880.

The population is purely a pastoral one, there being no manufacturing in the valley. The people live in villages and farm the adjacent lands, often to a distance of 5 miles or more from the town. This mode of living has its advantages from a social standpoint, but is inconvenient and wasteful of time in carrying on the farm operations. The average farms are comparatively small, seldom being larger than 40 acres, although there are a few large ranches of several hundred acres each.

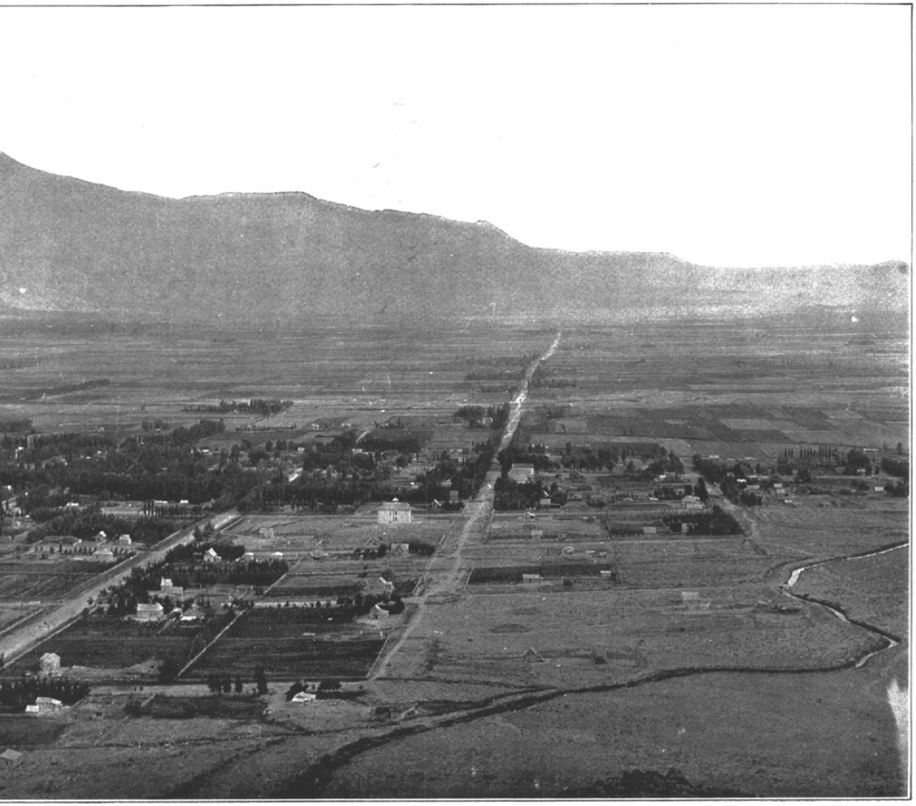
For the most part the valley is surrounded by a range country where thousands of sheep and a less number of cattle and horses find good pasture during the summers. As a consequence, the chief crops of the valley are alfalfa and grain used for feeding the stock brought into

the valley for the winter season. Alfalfa is first in importance both in acreage and in money value, while the cereals (oats, wheat, and barley) are the other chief crops. A few hundred acres of sugar beets were grown in 1900, and a movement is now in progress to establish a beet-sugar factory in the valley. As a rule, very little attention has been given to fruit raising, although a few small orchards are living examples of the good results that might be expected from this enterprise. At least enough fruit for home consumption should be grown. In the villages most of the houses have from 1 to 2½ acres of land, used for the production of all kinds of garden and vegetable products for home consumption. As a rule, the methods of farming are susceptible of great improvement. The farmers are lacking in enterprise, and should awaken to the fact that undeveloped opportunities lie close at hand. Better cultivation and larger yields should be sought.

At the south end of the valley the older canals are the Richfield, Elsinore, Brooklyn, Monroe, and Annabella. Two very important highland canals, the Sevier Valley on the west and the South Bend on the east, have more recently been constructed. Each canal is the joint property of the landowners and most of them were constructed by the cooperative labor of these owners. Each canal company elects officers, usually consisting of a president, secretary, board of directors, and water master, the last named being the only one paid for services rendered. It is the duty of the water master to see that the canal and its gates are kept in good repair and to apportion the water supply to the various shareholders. The annual assessment for repairs and maintenance rarely exceeds from 50 to 75 cents per share and is payable in work, material, or money.

Each canal receives from the river an amount of water proportional to its rights in the same. The proportioning of the water to the different canals is attended to by a river water master, who is elected and paid for services rendered by the various canal companies. When there is plenty of water each canal company gets all it wants, but when there is a shortage each company bears its proportional share of the same. The company water master adjusts the head gates of the various ditches taken from the canal so that each will receive water in proportion to the shares to which it supplies water.

A schedule is made out for the irrigation season for each ditch, showing the days and hours that each shareholder is entitled to use the water. A shortage of 25 per cent in the water supply for the canal means the same shortage for each ditch taken from it and does not change the schedule of the irrigation. Each share is supposed to irrigate 1 acre of land, but a man having 10 shares may use that amount of water on as much or as little land as he may choose. The furrow method of irrigation is used almost entirely, that is, small furrows, from 3 to 6 inches deep at intervals of from 2 to 2½ feet,



The Town of Elsinor,

extend down the sloping direction of the field, and the irrigation stream is broken up and turned into these small furrows at a rate just sufficient to keep the water running to the lower end of the furrows and yet not to waste it by running beyond. The water from the Sevier River at times contains considerable sediment, so that most of the canals taken from it are lined with sufficient sediment to prevent much leakage, and there is very little trouble from this source. The Richfield Canal, however, leaks considerably in the vicinity of Richfield, and is partly responsible for the land along the railroad from 1 to 2 miles south of the town that is damaged by alkali and seepage.

The Vermilion Canal, supplied chiefly by seepage water, is quite level, and becomes so filled with moss that the movement of water in it is often very slow. By letting the water out of the canal for one or two days the bright sun would kill the moss, and when the water was again turned in the moss would cause no trouble. Another effective way of getting rid of the moss is to run a disk harrow through the canal. This agitates the mud, which becomes entangled with the moss, and upon settling carries the moss to the bottom, where it offers no obstruction to the flow of the water.

The Rocky Ford Canal has one of the most constant and surest water supplies in the valley, the source being chiefly from springs that occur about Glenwood and northward along the base of the mountains on the east side of the valley. The canal is nearly 15 miles long and irrigates a narrow strip extending parallel to the river, aggregating between 3,000 and 4,000 acres. The West View, Dover, and Kearns & Robbins canals all depend on seepage waters during the drier portion of the year. The water of these canals is very salty and does not give good results, as is shown by the condition of most of the farms under them. The canals about Gunnison and Centerfield get their supply as follows: For 5,000 acres, from the San Pitch River; for 6,000 acres, from Six, Nine, and Twelve Mile creeks. Besides these there are a number of streams entering from the east, which furnish water for limited areas. Monroe Creek, Salina Creek, Willow Creek, and large springs at Richfield and Glenwood are important sources of water for small areas, aggregating not less than 3,000 acres.

ORIGIN AND FORMATION OF THE SOILS.

The general evenness of the valley is one of the first points observed, there being comparatively little slope between the bottom of the valley and the base of the mountains, excepting at the mouths of the small canyons. Some of the mountains are quite high, Monroe Peak being 11,240 feet in elevation, and are quite precipitous and craggy.

The range of mountains on either side contributes the material for the soils on their respective sides of the valley. From the predomi-

nating red sandstone of the mountains on the west side originate the red-colored soils there, while the darker soils on the east side of the valley find their origin in the dark-colored igneous and lava rocks which there predominate.

The mountains are closely set with small hollows and ravines between the larger canyons, from which, by the aid of rains and snows, the weathered rocks have been transported to the valley. Each of these canyons has a small alluvial cone of its own, the apex of which is generally made up of large stones and bowlders and the interstices filled with finer material. Near the periphery the soil is finer, with little or no gravel. The influence of the Sevier River is shown, there being a narrow strip of sandy soil along its course caused by the deposition of rock material carried down by the water. This sandy soil is sometimes covered to the edge of the river by the mountain soil.

The mountains all about the country have been very thoroughly shaken up. The strata of sandstone have been left in all conceivable conditions—vertical, horizontal, in curves, and at any angle between vertical and horizontal. During the upheaval at the end of the Cretaceous period the mountains on the sides were raised, while a deep canyon was formed where the valley now is, down which the waters rushed, filling the canyon with gravel and sand. The first filling would, of course, go on so rapidly that the disintegrated material from the side mountains would have but little effect in the process. At a later period, when the water grew less in volume and as the mountains became more disintegrated, they were the chief source of the soils of the valley. Borings to a depth of several hundred feet show chiefly sand and gravel, with an occasional stratum of clay. This may indicate that the water from the canyon above and from the surrounding mountains took turns in forming the soil, the water from the canyon doing very little while the strata of clay were being formed from the adjacent hills. The character of the rocks in the mountains and the fossils which they contain give evidence that both the valley and mountains were once on the same level, and both were submerged, first by fresh water and then by salt water.

Between Elsinore and Joseph the bed of the river is gravel, and when a stream large enough for an ordinary canal is turned into the dry river bed the water gradually and entirely disappears by sinking into the gravel. Water thus sinking in this part of the valley is the probable source of the large springs and artesian wells which occur further down the river in the vicinity of Richfield and Glenwood.

The material from the adjacent mountains varies in depth from 100 feet or more near the mountains to a thin covering near the limit of transportation, where it often covers the river soil.

The red color of the soil on the west side of the valley is due chiefly to the abundance of ferric oxide in it. The soils in their virgin state contain all the essential elements for crop purposes—nitrogen from

organic material; potash from feldspar; phosphorus from phosphate rocks; calcium from calcite, dolomite and calcareous sandstone; iron from iron oxides; magnesium from dolomite; sulphur from gypsum, and probably from other sulphates; as well as chlorine, silicon, and aluminum.

SOILS.

The soils have been classified, according to their texture and formation, into ten types, which are shown in different colors on the map. The names, areas, and descriptions of the soils follow:

Areas of the different soils.

Soils.	Area.	Per cent of total area.	Soils.	Area.	Per cent of total area.
	Acres.			*Acres.*	
Redfield sandy loam	44,200	29.4	Meadow land	10,200	6.8
Bingham gravelly loam	38,400	25.6	Elsinore sandy loam	7,800	5.2
Bingham stony loam	16,600	11.0	Redfield clay loam	3,800	2.5
Redfield loam	14,100	9.4	Elsinore sand	1,900	1.3
Glenwood loam	12,100	8.0	River wash	1,300	.8

While the soils contain all the mineral elements of fertility, in their virgin state they produce only a scanty vegetation because of the insufficient rainfall.

REDFIELD SANDY LOAM.

Redfield sandy loam embraces a greater area than any other one type of soil in the valley, there being about 44,200 acres, or 29.4 per cent of the whole area surveyed. This loam is confined to the west side of the valley. Beginning just north of Elsinore, it extends northward along the entire remaining length of the Richfield district and throughout the length of the Gunnison district. The soil is formed from the mountains to the west, and like them it is for the most part quite red in color. Generally it slopes more rapidly toward the river than the soils on the east side of the valley.

This type of soil occurs in two phases: One portion, a sandy loam, continuing about the same in texture for an undetermined depth, but sometimes underlaid by gravel at 3 feet or more below the surface; the other, a soil in which more or less rounded, medium-sized gravel occurs within 3 feet or less of the surface, often coming directly to the surface. Irrigation is confined almost entirely to the first-named portion of this soil, the larger part of which occurs in the Richfield district. There are also some areas along the lines of the Vermilion and Richfield canals in the vicinity of Aurora in the Gunnison district. A profile of this portion of the Redfield sandy loam to a depth of 6 feet shows it to be uniformly a sandy loam.

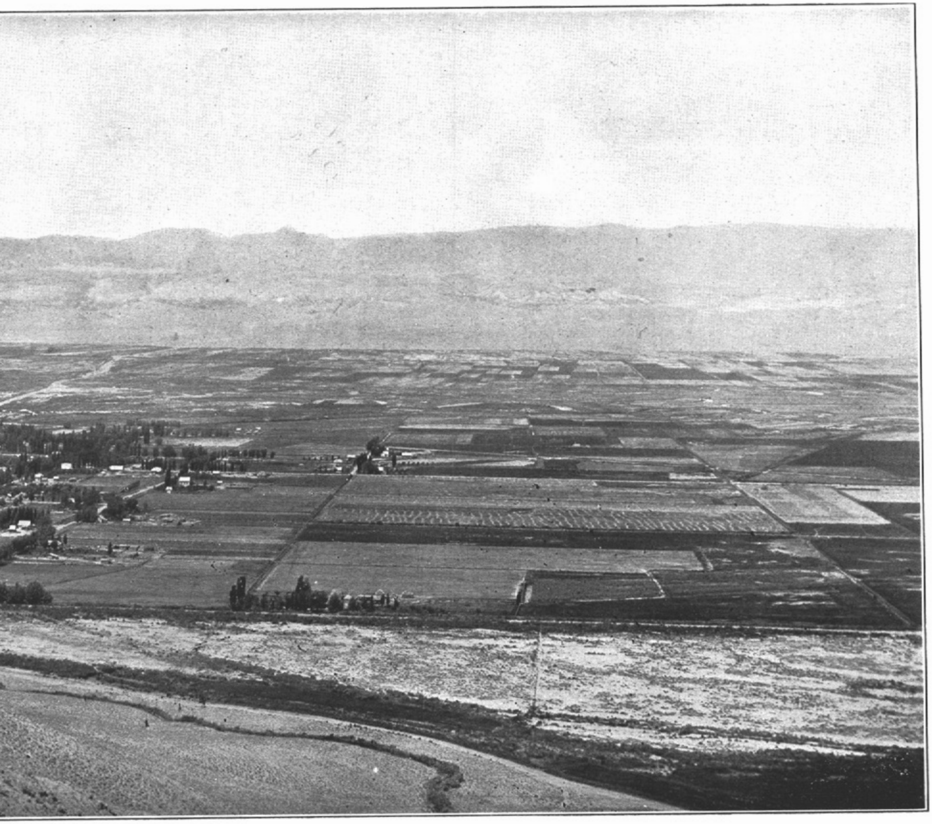
The following table of mechanical analyses shows the texture of the

soil to consist principally of the finer grades of sand and silt, with an average of about 12.4 per cent of clay. There is practically no difference in the texture of the different depths.

Mechanical analyses of Redfield sandy loam.

No.	Locality.	Description	Salt as determined in mechanical analysis.	Loss on ignition.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
	Soils, 0 to 12 inches in depth.		*P. ct.*	*P. ct.*	*P. ct*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4950	Near West View	Gravelly bench land (28.5 per cent of gravel).	0.39	7.56	6.55	5.78	12.91	21.01	28.40	12.19	5.20
4894	C. of NE. ¼ sec. 26, T. 23 S., R. 3 W.	Dry virgin land.	.43	7.43	Tr.	1.64	.48	9.98	43.39	28.17	7.76
4906	C. of SE ¼ sec 8, T. 23 S., R. 2 W.	do	.59	3.17	.87	2.81	3.39	17.34	27.47	32.42	11.67
4755	N. C. of sec. 22, T 24 S., R. 3 W.	Rough settled land	.50	4.11	Tr.	1.67	2.54	12.26	39.98	26.54	11.50
4752	do	Unsettled land	.54	5.90	Tr.	3.32	3.13	15.88	32.57	26.54	12.05
4738	S. C. sec. 10, T. 24 S., R. 3 W.	Rough settled land.	.36	6.72	.54	1.39	2.18	10.28	16.99	43.08	17.64
4928	¼ mi. W. of C. sec. 27, T. 21 S., R. 1 W.	Alfalfa land	.52	3.25	0.00	0.00	Tr.	1.30	22.82	50.98	20.93
	Mean		.45	5.45	1.14	2.52	3.52	12.58	30.27	31.42	12.39
	Subsoils.										
4895	Sandy loam. 24 to 36 inches.	Under No. 4894	.43	7.78	Tr.	2.15	1.35	16.50	30.40	28.40	12.93
4896	Sandy loam, 48 to 60 inches.	do	.49	4.86	Tr.	.88	.82	9.46	21.02	44.42	18.14
4907	Sandy loam, 24 to 36 inches.	Under No. 4906	3.10	7.09	Tr.	2.54	2.54	10.12	22.06	45.34	6.30
4908	Sandy loam, 48 to 60 inches.	do	1.84	9.83	Tr.	1.45	2.34	12.15	27.20	36.34	8.18
4756	Sandy loam, 34 to 36 inches.	Under No. 4755	.48	2.64	1.69	6.05	7.10	22.04	30.43	20.70	8.07
4757	Sandy loam, 48 to 60 inches	do	.54	5.93	2.26	5.53	5.78	17.55	27.02	26.06	10.05
4753	Sandy loam, 24 to 36 inches.	Under No. 4752	1.61	1.37	Tr.	2.26	3.95	22.58	38.00	20.63	8.50
4754	Sandy loam, 48 to 60 inches.	do	1.17	5.14	Tr.	1.16	2.53	16.24	40.07	25.93	7.46
4739	Sandy loam, 24 to 36 inches.	Under No 4738	.43	6.57	Tr.	4.59	5.60	18.63	26.44	28.11	9.87
4740	Sandy loam, 48 to 60 inches.	do	.42	4.57	Tr.	4.80	5.37	24.64	32.36	18.69	7.76
4929	Sandy loam, 24 to 36 inches.	Under No. 4928	.53	7.06	0.00	.51	.42	2.66	19.23	48.66	19.25
4930	Sandy loam, 48 to 60 inches.	do	.56	8.28	0.00	Tr.	1.71	11.20	21.37	43.80	12.78

While this type of soil is usually free from injurious amounts of alkali, yet there are certain areas shown on the alkali map where the salt content is sometimes as great as 1 per cent. These salty areas are chiefly along the Richfield Canal, some distance northeast of Richfield, and along the Vermilion and Rockyford canals between Aurora and Redmond. The alkali areas are largely under the irrigation canals and are cultivated to a considerable extent. Owing to the scanty water supply it requires several years of irrigation to sufficiently reclaim the land, by leaching out the salts, for the profitable



RIGATING CANAL IN THE FOREGROUND AND STRIP OF ALKALI LAND JUST BELOW, AND FERTILE FIELDS IN THE DISTANCE.

growth of crops. This type of soil, when free from injurious amounts of alkali, makes excellent land for alfalfa and grain. Between Elsinore and Richfield is a large area of this land which, upon the application of irrigation water, settled over a large part of its surface, the land thus being left in a very uneven condition. This settling was in places so great that the surface of the ground was sometimes lowered as much as 10 or 12 feet. This area lies directly below the mouth of Flat Canyon, and at some time not far remote a cloud-burst in the mountains evidently brought down large amounts of debris in the form of rocks, soil, and scrub cedars, which lodged there, after which disintegration continued, but without causing much settling of the material. When thoroughly wet the ground settles in a marked degree. A boring to a depth of 18 feet was made in an unsettled portion of this soil, and another boring, at a distance of 75 feet, was made where the soil had settled. The only difference apparent at the time was that the unsettled portion was loose and evidently contained cavities, while the settled portion was uniform throughout. The field determinations showed a considerably higher per cent of salts in the unsettled part.

In view of the frequent occurrence of gypsum in Flat Canyon, and of the statements made by certain farmers that a white material, which seemed to dissolve when irrigated, was frequently present in the lower depths of the soil, it was thought that deep borings might reveal that the settling was actually due to the occurrence of gypsum which dissolved upon the application of irrigation water and allowed the surface soil to settle. This material was not found in sufficient amount to make such a theory tenable, and the former explanation seems the more plausible.

The following table gives the composition of the water-soluble salts in the settled and unsettled portions of the soil at various depths:

Percentage composition of water-soluble salts.

Constituent.	Depth in virgin unsettled soil.							Depth in irrigated settled soil.					
	1 foot.	3 feet.	5 feet.	9 feet.	13 feet.	15 feet.	18 feet.	1 foot.	3 feet.	5 feet.	9 feet.	13 feet.	18 feet.
Ca	14	24	22	20	20	21	21	15	13	17	21	20	20
Mg	3	2	3	3	4	3	3	3	4	3	2	4	1
Na	7	2	2	3	3	1	3	5	6	3	4	2	1
K	3	1	2	3	1	6	2	4	4	2	3	3	4
SO_4	4	66	64	61	64	61	62	6	8	7	52	59	62
Cl	7	1	2	3	3	3	3	6	3	7	2	1	1
CO_3	2	1	1	0	0	0	0	1	3	0	0	0	0
HCO_3	60	3	4	7	5	5	6	60	59	62	17	11	8
Per cent soluble	0.67	1.57	0.85	0.75	1 13	0.97	0.92	0.25	0 19	0.20	0.40	0.53	0.82

The second, or gravelly, phase of this soil lies usually above the present canal systems, and occurs principally in the Gunnison dis-

trict. It has a considerable slope as far north as Redmond, north of which it takes the form of a bench, with a terrace along the eastern border. With the exception of a small and comparatively low portion near the junction of the San Pitch and Sevier rivers, this area is free from injurious amounts of salts. The vermilion color so pronounced about Richfield becomes more somber to the north, probably owing to the presence of less of the oxides of iron, which give rise to the color.

BINGHAM GRAVELLY LOAM.

This type of soil ranks second in extent and first in agricultural value. It includes 28,400 acres, or 25.6 per cent of the area surveyed. It is divided into two phases of about equal extent—one of a dark color, occurring in the Richfield district and also in the Gunnison district as far north as Lost Creek; the other of a light color, occurring in the last-mentioned district from Lost Creek northward. The first phase is the predominating type of soil in the southern part of the Richfield district, and occurs at intervals in small tracts along the east side of the valley as far north as Lost Creek, in the Gunnison district. It is usually of a dark color, in contradistinction to the light-colored Elsinore sandy loam and the red-colored Redfield sandy loam which occurs on the west side of the valley. The dark color is due chiefly to its origin—the lava rocks from the adjacent mountains.

In the vicinity of Joseph and Monroe this type of soil is quite generally gravelly, the gravel being, as a rule, small and more or less rounded, so that it does not interfere with cultivation, even when it occurs immediately at the surface, which it often does. The gravelly areas on the map show gravel within 3 feet or less of the surface. All of this type of soil occurring south of Annabella is underlaid with gravel at a depth rarely greater than 10 feet. In the vicinity of Glenwood the gravel is less abundant. A profile of the soil to a depth of 6 feet shows, on an average, continuous sandy loam with gravel below 2 feet. It must of course be recognized that gravel sometimes occurs throughout the profile, while in other cases it is entirely absent.

A large percentage of this land is under cultivation, and gives excellent results with both alfalfa and grain. In its lighter and more gravelly portions it is well adapted to fruits. Three miles southwest of Monroe is a nursery and fruit farm, on which apples, pears, peaches, and various kinds of small fruits are doing well. The land is easy of cultivation and retains moisture remarkably well.

The following table shows the texture of this phase of the soil, as

determined by the mechanical analyses of samples from different parts of the area:

Mechanical analyses of Bingham gravelly loam, dark-colored phase.

No.	Locality.	Description.	Salts as determined in mechanical analysis	Loss on ignition.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
	Soils 0 to 12 inches in depth.		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4731	One-fourth mile N. of SE. C. sec. 14, T. 25 S., R. 4 W.	Cultivated land (gravel 27.5 per cent).	0.26	2.72	0.00	1.69	3.49	28.11	41.36	16.06	6.61
4735	SE. C. sec. 17, T. 25 S., R. 3 W.	....	.47	1.88	15.16	13.36	9.22	22.40	17.18	14.10	7.07
4733	C. of sec. 28, T. 25 S., R. 3 W.	Cultivated land (gravel 11.8 per cent).	.27	2.19	12.48	14.54	9.60	25.84	18.03	9.39	7.35
4744	C. of NE. ¼ sec. 5, T. 25 S., R. 3 W.	Cultivated land (gravel 8 per cent).	.43	4.52	2.03	2.58	4.72	28.09	22.11	23.65	12.70
4726	One-fourth mile N. of C. sec. 14, T. 25 S., R. 4 W.	Good alfalfa land.	.35	5.33	0.00	1.76	1.62	7.94	34.38	35.36	13.69
	Mean..........	....	.36	3.33	5.93	6.79	5.73	22.48	26.61	19.70	9.58
	Subsoils.										
4732	Sandy loam, 24 to 40 inches.	Under No. 4731...	.26	3.35	0.00	Tr.	1.29	12.76	43.20	33.01	5.62
4734	Sandy loam, 12 to 36 inches.	Gravel 10.3 per cent under No. 4733.	.35	3.75	3.02	3.01	2.80	9.50	17.28	38.10	22.11
4745	Sandy loam, 24 to 30 inches.	Gravel 30 per cent under No. 4744.	.51	3.46	3.68	6.60	5.83	26.60	27.26	20.74	5.00
4727	Sandy loam, 18 to 36 inches.	Under No. 4726...	.31	2.62	5.65	14.05	10.28	25.49	19.87	13.09	8.35

A glance at the salt map shows that, with the exception of a small area in sec. 1, T. 25 S., R. 4 W., and a strip west of Glenwood along the west side of Cove Creek, this type of soil as it occurs in the Richfield district is quite free from injurious amounts of salts. In the Gunnison district, however, a considerable amount of it is salty, especially near Lost Creek. In the salty areas the soil is usually virgin, and when brought under irrigation can be quite readily reclaimed, the salt being carried down into the usually porous subsoil.

The physical characteristics of the second phase of this soil are much like the former in regard to texture, gravel content, and mode of formation; but the color of the soil, the material from which it was formed, and the character of its salt content are very different. It is situated almost entirely in the Gunnison district and its water supply is derived chiefly from the San Pitch River and tributaries, together with small amounts from Saline and Willow creeks.

The origin of the soil is from the San Pitch Valley or from the mountains on the east. The soil is usually of a light-brown color

and, as will be seen by the map, contains gravel within 3 feet or less of the surface over most of its extent. In the vicinity of Centerfield the gravel is quite large and very well rounded. It was deposited there by the San Pitch River and continues to 100 feet in depth and perhaps several hundred feet deeper.

As a rule, even in the virgin state the higher parts of this area contain very little salt. This is largely due to its good slope and gravelly underlying stratum. In its lower depths, however, there is considerable salt, as shown by the character of the surface well waters. The lower and more level parts of the area are more or less salty in their virgin state, but are readily reclaimed upon the application of irrigation water. A glance at the alkali map will show that in secs. 12–20 and 30, T. 20 S., R. 1 E., there is considerable salty land, and also in sections 2 and 3 there are small areas having from 2 to 4 per cent; this salt, however, will readily disappear under judicious irrigation. A little more than one-third of this phase is now under irrigation, and the Highland Canal, which is now constructed to a short distance below Willow Creek, will bring a large additional area under the plow. This latter portion is usually light in texture, gravelly, and well adapted to the production of sugar beets, vegetables, and fruits. The lower part of this area is better suited to the production of alfalfa and cereals.

The following table of mechanical analyses gives an idea of the texture of this phase of the Bingham gravelly loam:

Mechanical analyses of Bingham gravelly loam, light-colored phase.

No.	Locality.	Description.	Salts as determined in mechanical analysis.	Loss on ignition.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.01 mm.	Clay, 0.005 to 0.0001 mm.
	Soils 0 to 12 inches in depth.		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct*	*P. ct.*
4938	SE. ¼ of sec. 16, T. 20 S., R. 1 E.	Gravelly virgin land, gravel 10 per cent	0.47	4.44	1.78	2.64	4.88	15.18	39.57	22.01	6.93
4945	NW. ¼ of sec. 28, T. 19 S., R. 1 E.	Cultivated gravelly land, gravel 21 per cent.	.50	9.00	6.02	5.08	3.98	11.52	20.08	32.80	12.47
4946	C. of sec. 23, T. 19 S., R. 1 E.	Virgin soil	1.80	7.77	Tr.	1.06	1.28	9.67	32.39	27.84	18.55
4939	W. C. of sec. 2, T. 20 S., R. 1 E.	do	.32	6.53	Tr.	.68	.79	5.05	21.56	41.12	25.47
	Mean		.77	6.93	1.95	2.37	2.73	10.36	28.40	30.94	15.85
	Subsoils.										
4947	Sandy loam, 24 to 36 inches.	Under No. 4946	1.93	8.81	1.14	.91	1.38	4.52	29.45	38.59	13.29
4948	Sandy loam, 48 to 60 inches.	do	1.31	8.81	5.67	5.93	4.10	7.62	23.42	27.23	16.93
4940	Sandy loam, 24 to 36 inches.	Under No. 4939	1.97	3.81	.70	2.38	2.52	14.65	35.52	24.19	14.24
4941	Sandy loam, 48 to 60 inches.	do	3.61	5.08	1.92	2.34	4.60	12.81	33.10	23.94	10.17

Sample 4939 shows too much clay in the top foot for a sandy loam; this, however, is only of local occurrence and is caused by a recent covering of fine material which has been brought down from the canyon just to the east and lodged in a flat area at this point. Just here is also a salty area, as will be seen from the alkali map. The third and fifth foot beneath, samples 4940 and 4941, are very much lighter in texture and are quite representative of sandy loam. Sample 4946 is also somewhat heavy for a sandy loam, but the soil becomes lighter below. These samples are from portions of this type of soil where the gravel is 5 feet or more from the surface and represent the heavier part of the soil. Samples 4938 and 4945 are from parts where the gravel is 3 feet or less from the surface and where the soil is much lighter in texture.

A profile representing the average character of this type of soil to the depth of 6 feet would be 3 feet of sandy loam, then 3 feet of sandy loam with gravel, continuing to an undetermined depth.

BINGHAM STONY LOAM.

The Bingham stony loam is located along the base of the mountains and occurs chiefly in the Richfield district. The material is derived mostly from the adjacent mountains, although at the mouth of canyons it is sometimes brought down from the interior of the mountain ranges. This land consists of a mixture of loam, sand, and gravel, in which is embedded loose rock coming directly to the surface or sometimes projecting above it. Near the base of the mountains it is usually underlaid with the bed rock of the mountains themselves, while farther out into the valley the same material often continues to a considerable depth. This land is of very little agricultural value—first, because it is usually too stony to be successfully cultivated, and second, because it is usually situated above the highest irrigation canals, and therefore can not be watered. It is so dry and the vegetation is therefore so scanty that the value of the land for grazing is small.

In several localities there are small streams issuing from the adjacent mountains that could be used for irrigating some of this class of land, but where the water can be used on better lands lower down it is advisable to use it there. South of Monroe there are nearly a thousand acres of this land under the ditches taken from the Monroe Canyon, a portion of which could be successfully used for orchards, especially for the stone fruits, such as peaches, plums, etc. As shown by the alkali map, the Bingham stony loam is usually free from injurious amounts of alkali.

REDFIELD LOAM.

This loam originates from the red sandstone mountains to the west, as does the Redfield sandy loam which lies just above it. It occurs from Elsinore northward to the town of Vermilion, in the Richfield

district, and also in the Gunnison district for the greater part of its length. It covers an area of about 14,100 acres, or 9.4 per cent of the area surveyed. It lies below irrigation canals and is capable of cultivation; in fact a large percentage of it is being successfully cultivated. In the vicinity of Richfield and northward a considerable portion of this land is somewhat wet, the ground water standing within 3 feet or less of the surface. In these areas underdrainage would be of material assistance in improving the condition.

The alkali map shows that very little of this type of soil between Elsinore and Richfield is seriously troubled with alkali; northward from Richfield, however, much of it is quite salty, and generally in its virgin state it is covered with a good growth of greasewood and contains from 0.6 to 1 per cent of alkali. Both the Vermilion and Rockyford canals irrigate considerable portions of this land, and the alkali map shows many square or rectangular areas that differ in salt content from the adjacent land. This is due to the practice of irrigation, which is reclaiming this land in tracts of from 20 to 40 acres.

A profile of this soil shows an average of 4½ feet of loam underlaid by clay loam. In some instances the loam is continuous to great depths, while in others it is underlaid by sandy loam or sand. The latter condition is found where the loam borders on a soil of lighter type, which in some cases it overlaps, although it is more frequently overlapped by the lighter soil. This soil, especially when wet, is of a striking vermilion color.

The following table shows the texture of a number of samples which were taken from these areas. The heavy texture is not all accounted for by the clay content; but it will be noticed that the silt content is very high, averaging about 50 per cent of the total separations.

Mechanical analyses of Redfield loam.

No.	Locality.	Description.	Salts as determined in mechanical analysis.	Loss on ignition.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
	Soils 0 to 12 inches in depth.		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4910	W. C. sec. 10, T. 23 S., R. 2 W.	Alfalfa land	1.49	6.61	0.00	Tr.	Tr.	0.85	5.75	55.99	28.64
4925	¼ mile N. of C. sec. 28, T. 24 S., R. 3 W.	do	.52	4.10	0.00	0.46	0.64	5.90	25.46	48.14	14.82
	Subsoils.										
4911	Loam, 24 to 36 inches	Under No. 4910	1.15	9.54	0.00	0.00	Tr.	1.74	5.93	55.04	26.81
4912	Loam, 48 to 60 inches	do	1.41	12.16	0.00	0.00	Tr.	.94	5.88	51.73	29.29
4926	Loam, 24 to 36 inches	Under No. 4925	.35	2.40	0.00	.76	.80	6.42	25.26	43.68	14.61
4927	Loam, 48 to 60 inches	do	.45	6.84	Tr.	1.26	2.46	14.51	22.01	41.28	11.76

View up the Valley from the Heights west of Gunnison,

GLENWOOD LOAM.

This type of soil, embracing 12,000 acres, or 8 per cent of the area surveyed, is of the same origin as the Bingham gravelly loam, being the finer material from the latter, which has been laid down at a greater distance from its source. Like the Bingham gravelly loam, it is also divided into two phases of corresponding origin. The first phase is the dark-colored soil which occurs in the Richfield district.

A profile of this portion shows about 4 feet of loam underlaid by clay loam. As a result of this heavy substratum, the work of reclaiming the virgin land when salty is rather slow, but when reclaimed it produces excellent yields of alfalfa and grain.

A comparison of the soil and alkali maps shows that from north of Monroe to Annabella this type of soil is quite free from injurious amounts of salts. That portion in the vicinity of Glenwood and northward, however, is not only salty but is very wet, and needs drainage before it can be successfully cultivated. That portion near Lost Creek is mostly under cultivation, but part of it has sufficient salt—from 0.20 to 0.40 per cent—to prevent uniform stands of crops grown. The trouble here is partly caused by the salty water from Lost Creek, which is used for irrigation.

The second phase of this type occurs in the Gunnison district. Its origin is from the same source as the second phase of the Bingham gravelly loam, being the finer materials from this loam which in the process of formation have been carried farther down before lodging. In the vicinity of Centerfield there is a small area where gravel occurs within 3 feet or less of the surface. Beyond this locality the gravel seems to have been suddenly covered, and while it may continue to the river it is either at that point at a very great depth or, possibly, entirely absent.

The following analyses show the texture of samples for the first and third foot, these samples being fairly representative of the texture of the gravelly portion of this type of soil. In the vicinity of Centerfield this land is all under cultivation and produces excellent yields of alfalfa and grain. A comparison of the soil and alkali maps shows that a considerable portion of this soil, where it borders on the meadow lands, is salty. It is not so readily reclaimed as the lighter soils, being heavy of texture, but it wears better, and for grain and alfalfa it is more productive than the lighter soils.

Mechanical analyses of Glenwood loam.

No.	Locality.	Description.	Salts as determined in mechanical analysis.	Loss on ignition.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
	Surface soil, 0 to 12 inches in depth.		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4749	¼ mile W. of S. C. sec. 3, T. 25 S., R. 3 W.	Grain and alfalfa land.	0.46	5.16	1.56	1.76	1.72	7.59	13.25	46.10	23.80
4943	C. of sec. 30, T. 19 S., R. 1 E.	Cultivated land.	.82	10.05	0.00	Tr.	.52	2.52	9.29	45.13	31.41
	Subsoils.										
4750	Loam, 24 to 36 inches.	Under No. 4749.	.86	4.61	1.88	2.68	1.52	6.88	15.56	44.22	22.87
4751	Loam, 48 to 60 inches.	......do..........	.60	3.42	2.80	3.82	2.45	10.44	17.90	39.15	20.38
4944	Loam, 24 to 36 inches.	Under No. 4943.	.66	8.32	0.00	0.00	Tr.	2.56	8.85	50.06	30.74

MEADOW.

The meadow land is an alluvial soil lying along the borders of the river, to which it chiefly owes its origin. It begins in the northeast corner of the Richfield district and widens to the north, extending the entire length of the Gunnison district. Its total area is 10,200 acres, or about 6.8 per cent of the entire area surveyed. In the vicinity of Redmond and for 3 or 4 miles northward there is considerable of this land cultivated; with this exception it is mostly in the virgin state, and is covered principally with salt grass and willows, the latter growing only where the salt content is less than 0.4 per cent. In texture it varies from a very light sandy loam to clay loam, but is usually a sandy loam, becoming slightly lighter in texture as the depth increases. It contains much organic matter in the upper portion, and consequently is of a black color. It is invariably salty, as shown by the alkali map, and becomes more so toward the north. As a rule, standing water is found to be 6 feet or less below the surface, although in T. 19 S., R. 1 W., there is considerable land where the water is not more than 3 feet from the surface. When the Sevier River rises, this land is no doubt somewhat wet.

With a good water supply and underdrainage it could be made into profitable farming land. There are a few good fields of grain and alfalfa near where Willow Creek enters the Sevier River that indicate the possibilities of this type of soil. The alkali is of the white kind and consists largely of chlorides, which have apparently come down from the salt hills and salty lands about Salina and have been left in the meadow lands by the seepage that there evaporates.

The following table shows the texture of this type of soil south of Redmond, which is probably somewhat lighter than the average:

Mechanical analyses of meadow land.

No.	Locality.	Description.	Salts as determined in mechanical analysis.	Loss on ignition.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4934	N. C. of sec. 23, T. 21 S., R. 1 W.	Virgin salt grass land, 0 to 12 inches.	1.92	8.11	0.00	0.00	1.11	14.95	30.21	30.37	9.10
4935	Sandy loam, 24 to 36 inches.	Under 4934	.95	3.30	0.00	0.00	1.28	36.44	41.88	7.40	7.83
4936	Sandy loam and sand, 48 to 60 inches.	do	.91	3.33	0.00	Tr.	2.10	36.46	45.07	7.83	4.90

ELSINORE SANDY LOAM.

This type of soil is confined to the Richfield district. It comprises about 7,800 acres, or 5.2 per cent of the whole area surveyed, extending along the river in the eastern part of the valley from a point east of Elsinore northward to the vicinity of Vermilion.

The origin of this type of soil is far up the valley, the material having been brought down by the Sevier River. The coarse sand and gravel were left between Joseph and Monroe and the finer material brought down to form this area. The surface of this soil is a light-colored sandy loam, varying in clay content from 5 to 15 per cent, as shown in the following table of mechanical analyses. The underlying stratum, however, becomes more sandy as the depth increases, and at 6 feet it usually grades into gravel. The character of the underlying stratum is clearly shown for the depths of 3 and 5 feet in the analyses.

Mechanical analyses of Elsinore sandy loam.

No.	Locality.	Description.	Salts as determined in mechanical analysis.	Loss on ignition.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
	Surface soil, 0 to 12 inches in depth.		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4900	One fourth mile N. of E. C. sec. 31, T. 23 S., R. 2 W.	Salt grass land	3.35	6.17	0.00	2.33	3.97	19.92	32.80	26.95	5.19
4903	One-fourth mile S. of C. sec. 33, T 23 S., R. 2 W.	Low wet land	.86	7.90	.00	1.22	1.91	9.91	24.06	46.27	8.01
4914	SW. ¼ of sec. 22, T. 23 S., R. 2 W.	Salt grass land	1.05	3.74	Tr.	1.38	3.24	28.24	31.48	19.06	12.17
4741	One-fourth mile W. of C. sec. 13, T. 24 S., R. 3 W.	Low wet land	1.12	5.72	.00	Tr.	.44	2.54	32.60	44.92	12.31
4897	One-fourth mile S. of C. sec. 6, T. 24 S., R. 2 W.	Low level land	4.10	8.22	Tr.	.58	.63	11.58	21.60	37.63	15.21
	Mean		2.10	6.35	.00	1.10	2.04	14.44	28.51	34.97	10.58
	Subsoils, 24 to 36 inches in depth.										
4901	Coarse sand	Under No. 4900	.75	2.17	8.70	13.87	10.69	34.64	15.54	10.84	2.51
4904	Sandy loam	Under No. 4903	.58	4.14	.00	Tr.	.42	2.39	30.59	53.98	7.98
4915	do	Under No. 4914	1.08	3.38	.00	Tr.	.32	35.86	37.71	16.02	6.44
4742	do	Under No. 4741, gravel 8 per cent.	.75	3.23	Tr.	1.80	1.69	29.43	40.00	17.80	5.91
4898	do	Under No. 4897	1.92	5.78	2.87	4.36	2.37	21.35	33.35	21.94	6.20
	Mean		1.02	3.74	2.31	4.01	3.10	24.73	31.44	24.12	5.81
	Subsoils, 48 to 60 inches in depth.										
4902	Sand and gravel	Under No. 4900	.55	1.15	21.50	27.00	18.34	24.08	5.03	.69	.76
4905	Sandy loam	Under No. 4903	.57	6.25	.00	Tr.	.20	2.69	36.40	47.35	8.22
4916	Loam	Under No. 4914	1.00	5.05	.00	Tr.	.80	22.21	33.41	28.20	10.63
4743	Coarse sand	Under No. 4741, gravel 9 per cent.	.46	1.76	7.00	15.88	14.34	33.07	19.60	4.34	3.18
4899	Sand	Under No. 4897	.67	2.84	5.46	9.64	8.35	40.90	16.23	11.88	3.16
	Mean		.65	3.41	6.79	10.50	8.41	24.59	22.13	18.49	5.19

Notwithstanding the very pervious character of the underlying stratum of this soil, under much of it water is found standing within 6 feet or less of the surface, and in secs. 28, 32, and 33, T. 23 S., and sec. 5, T. 24 S., there is a large area where the water is 3 feet or less from the surface. This wet condition has been ascribed to two sources, the chief of which is the large number of springs that occur all along the base of the mountains from Annabella northward to the point of the mountain west of the town of Glenwood. These springs not only keep the soil wet but send seepage to the river, which is later taken out and used for irrigation. On the west side of the river this soil is

somewhat affected by seepage from the canals and irrigated lands along the west side of the valley, especially from the district between Elsinore and Richfield.

A glance at the alkali map shows that most of this type of soil is more or less salty, the larger percentage of it having from 0.2 to 0.4 per cent of salts, with small areas having as much as 1 per cent. The larger part of the salts occur in the surface foot, salt crust being present at the surface in many places. The alkali is chiefly of the white kind, the black alkali being found only in small amounts. The source of these salts is largely the accumulating water, which evaporates from the wet soil and leaves its salts at or near the ground surface.

In its present condition this type of soil is of very little value, and indeed less than 1 per cent of it is farmed. Most of it produces a considerable growth of salt grass, which is used for pasturage or for hay. With very little drainage and with the application of irrigation water this land could be quickly and easily reclaimed and would make fair farms, especially for sugar beets and vegetables.

A drainage canal to collect the waters of the springs along the base of the mountains and conduct them into Cove Creek would be the first necessary step in the process of reclaiming the land. In this event the water for irrigating the land would probably have to come through an extension of the Annabella, Monroe, or South Bend canals.

REDFIELD CLAY LOAM.

This heavy type of soil occurs principally in the Richfield district and in the vicinity of the town of Redfield. While in places the clay loam continues to a considerable depth, yet it is more frequently underlaid by sand at a depth of 5 feet. Owing to its heavy character it contains much salt, which is difficult to remove. In the vicinity of Richfield it has become sufficiently free from salts to produce grasses. Even where salty, a good crop of salt grass used for pasturage is grown. Generally, this type of soil is wet, the water standing within 6 feet or less of the surface.

The following table shows the texture of the soil as determined by the mechanical analyses:

Mechanical analyses of Redfield clay loam.

No.	Locality.	Description.	Salts as determined in mechanical analysis.	Loss in ignition.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
	Surface soil, 0 to 12 inches in depth.		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4728	C. of sec. 23, T. 24 S., R. 3 W.	Level irrigated land.	0.83	9.19	0.00	Tr.	0.56	3.10	12.77	53.79	18.39
4891	C. of SE. ¼ sec. 2, T. 24 S., R. 3 W.	Wet salt grass land.	2.25	6.21	.66	0.92	.48	1.44	2.20	51.78	34.59
	Subsoils.										
4729	Clay loam, 24 to 36 inches.	Under No. 4728	1.87	7.09	.00	.00	Tr.	1.76	12.51	51.02	25.60
4730	Clay loam, 48 to 60 inches.	do	1.80	8.86	.00	Tr.	.61	1.67	7.76	54.98	24.48
4892	Clay loam, 24 to 36 inches.	Under No. 4891	1.44	5.71	.00	Tr.	.38	1.75	4.06	48.60	38.06
4893	Clay loam, 48 to 60 inches.	do	1.58	9.74	.00	.00	Tr.	1.86	4.09	50.69	31.46

ELSINORE SAND.

Another unimportant type of soil is the Elsinore sand, located along the river bank in the southern half of the Richfield district only. It constitutes about 1,900 acres, or only 1.3 per cent of the entire area surveyed. It is a coarse river sand, sometimes containing river-washed gravel, and always underlain by gravel. It is too leachy in character to be of much value for agricultural purposes.

RIVER WASH.

This soil, as the name implies, is practically nothing but a large amount of coarse river-washed gravel, with only a small percentage of fine material intermixed. In places there is sufficient fine material to make cultivated areas, but, as a rule, it is practically valueless for agricultural purposes. It occurs only in the Gunnison district and along the San Pitch River bed.

WATER SUPPLY.

The irrigation water supply for the Sevier Valley is, under its present management, inadequate to irrigate all of the land included in the present survey. By impounding all of the water from the close of the irrigation season to the opening of the same the next year, there would unquestionably be sufficient water to irrigate all of the land,

and in years of the greatest precipitation leave some to spare. Such an impounding of the water has already been commenced on Otter Creek, an important tributary of the Sevier. A reservoir is there formed by building a large dam across the creek near where it enters the Sevier River. The dam, now nearly completed, is of earth and stone, with a clay "core," which is well pounded. At its base the dam is about 200 feet wide, and the sides have a slope of 2½ to 1, making the height of the dam 40 feet. Crosswise of the stream the dam at its base is 150 feet long; at an elevation of 35 feet, 900 feet long, and at 40 feet in height, about 1,200 feet long.

When filled to the top of the dam the water of the reservoir extends up the Grass Valley a distance of 6 or 7 miles, with an average width of three-fourths of a mile, giving a capacity of slightly more than 41,000 acre-feet. The cost of the reservoir thus formed will be about $40,000.

It is now thought that the height of the dam can be increased to 45 feet, at which height the capacity of the reservoir will be about 60,000 acre-feet. This reservoir is designed to collect all of the waters from the Grass Valley, and, by means of a feeder canal, water is also conducted to it from the south fork of the Sevier River.

The water from the Grass Valley flows down through the meadows and is free from silt, so there will be no danger of the reservoir filling with this material. The construction of this important work materially increases the available water supply for irrigation and marks an important improvement.

During the winter and spring of 1899–1900 the precipitation of both rain and snow was unusually small, and the dam, although incomplete, was sufficient in height to retain all of the water from Grass Valley. The gates of the reservoir were opened June 1 and the water allowed to escape at the rate of 160 cubic feet per second. The flow continued at this rate until July 15, when the water was nearly exhausted. At the latter date the flow of the Sevier River, exclusive of the reservoir supply, was only about 30 second-feet. The water from the reservoir flows about 45 miles in the river bed before the first important canal takes it.

All of the principal canals in the upper part of the district have an interest in the reservoir and receive water from it, according to their proportional part of the entire capital stock. The following table gives the valuation of the capital stock for each canal; the percentage of same to the total; also the percentage of the normal river flow to

which each is entitled when said flow below Joseph is less than 101 second-feet:

Distribution of stock in Otter Creek reservoir.

Name of canal.	Capital stock in Otter Creek reservoir.	Percentage of capital stock.	Percentage distribution of Sevier River water when below 101 acre-feet.
Joseph Irrigation Co	$2,454	5.6	10.0
Sevier Valley Canal Co	7,291	16.7	
South Bend Canal Co	6,734	15.5	
Monroe Canal Co	5.413	12.4	19.0
Brooklyn Canal Co	2,747	6.3	11.5
Elsinore Canal Co	2,008	4.5	7.0
Richfield Canal Co	11,343	26.0	35.5
Wells Canal Co	1,314	3.0	4.5
Annabella Canal Co	951	2.2	10.5
Vermilion Canal Co	2,108	4.8	
Rockyford Canal Co	1,201	2.7	
Isaacson Canal Co			1.5
Higgins Canal Co			.5
Total	43,564		

On the San Pitch River, between Manti and Sterling, there is a reservoir which has been used for several years, and, while not so large as the Otter Creek reservoir, it is an important adjunct to the irrigation about Gunnison and Centerfield.

The water for all canals taken from the river above Elsinore is excellent in quality, even in its lowest stage, for irrigating purposes. As is usually the case with river water, it contains least total salts when the volume is greatest, and most when the volume is smallest. In general, the percentage of salts also increases farther down the stream. Sketch maps (figs. 25 and 26) show the depth to standing water and the salt content of irrigation waters in different parts of the valley.

On June 1, 1900, the water from the two upper canals, the South Bend and the Sevier Valley canals, was found to contain 16 parts[1] of salts. Of this, 8 per cent was sodium carbonate (black alkali); 40 per cent was bicarbonate, probably mostly of calcium; 25 per cent was chloride, and the remaining 27 per cent was principally sulphates. Of the bases, lime, as determined later by chemical analyses, constituted more than half. Of these salts, the carbonate is the most injurious, while the bicarbonate is probably the least so. Both the carbonates and the bicarbonates, however, are very unstable, and are readily changed from one to the other.

[1] In this paper parts of salt refer to the parts in 100,000 parts of water.

Natural Vegetation of Greasewood on Alkali Land.

In water, the presence of much carbon dioxide will convert the carbonates to bicarbonates, while the reverse condition will change them back again. In the soil, conditions of moisture, temperature, and the presence of other salts have a marked influence upon the relation of carbonates to bicarbonates. With good drainage and aeration, the

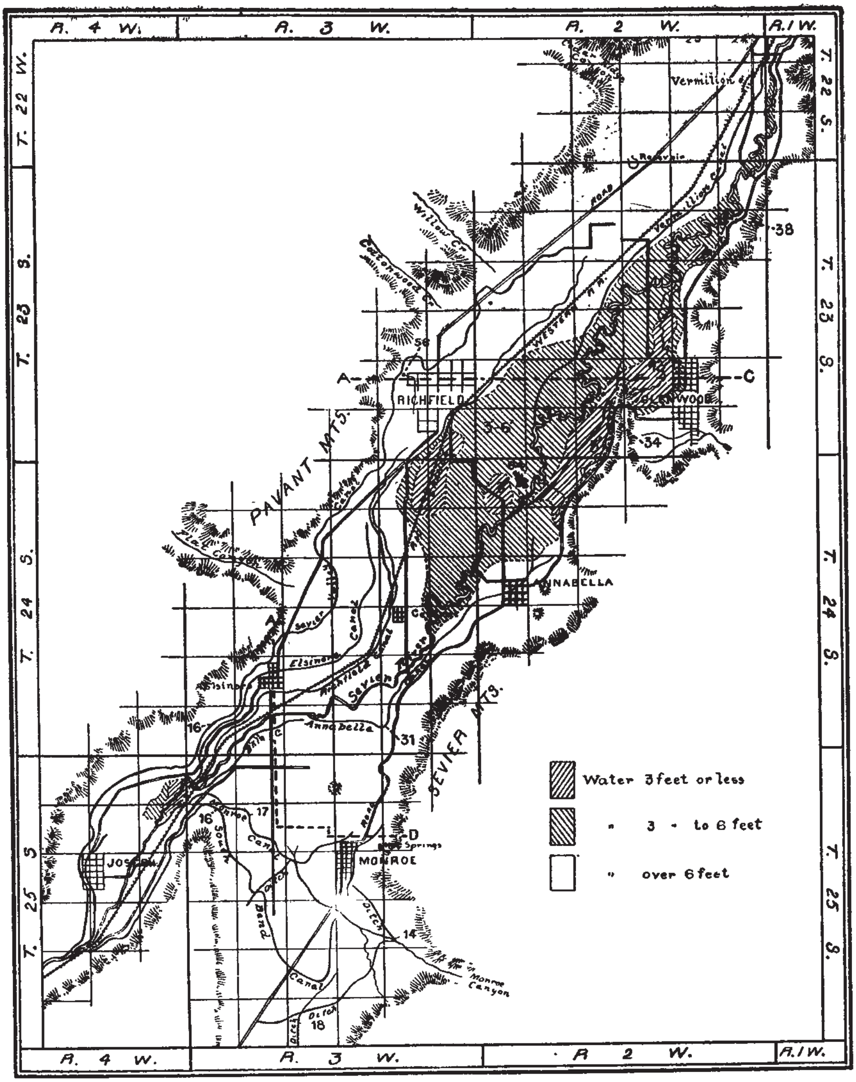


FIG. 25.—Sketch map of Richfield sheet, showing depth to standing water and salt content of irrigation waters in parts per 100,000.

presence of calcium sulphate changes sodium carbonate in part to sodium sulphate, which is much less harmful and which gives rise to carbonate of lime, which is so slightly soluble as to be harmless. The presence of carbon dioxide in the soil is also favorable to the conversion of the carbonates to the bicarbonates.

On the date of the above examination the water from the Brooklyn and Annabella canals was found to carry 32 parts of salt, or twice as much as that of the upper canals. This increase in salts is due to a small amount of seepage, carrying a considerable amount of salts,

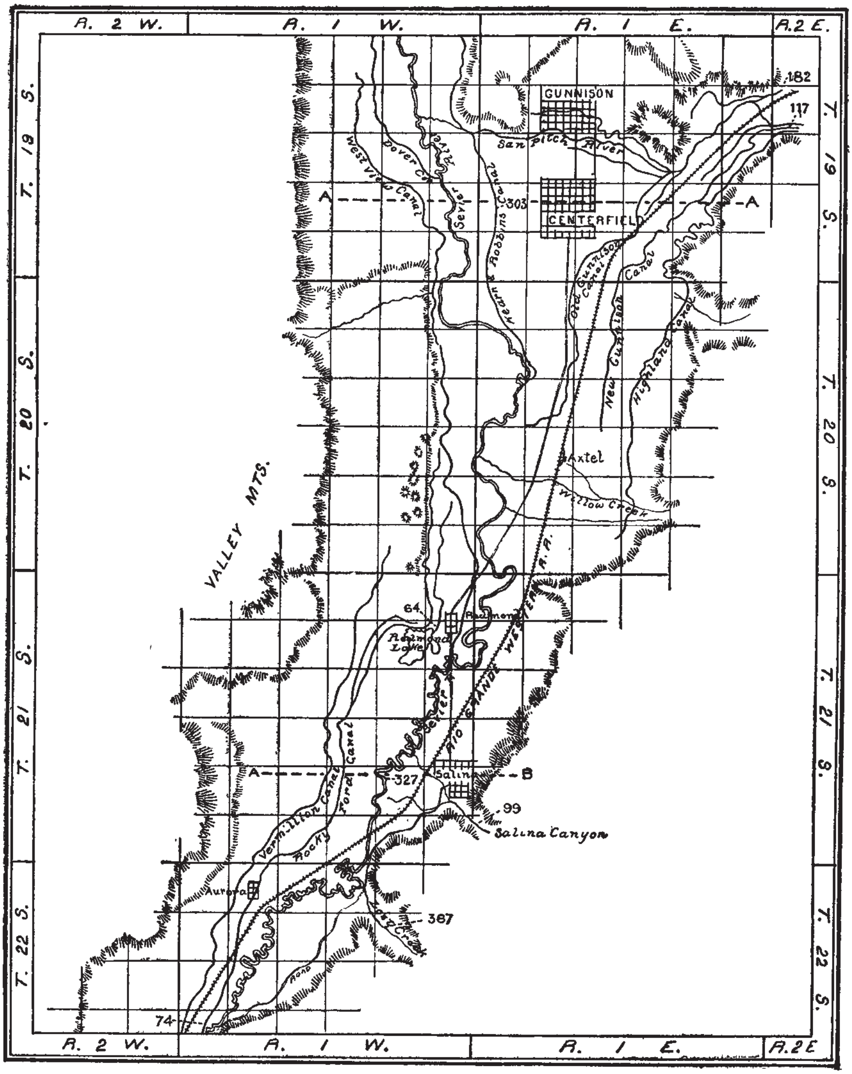


FIG. 26.—Sketch map of Gunnison sheet, showing salt content of irrigation waters in parts per 100,000. (No standing water within 6 feet of surface.)

which enters the river bed from the vicinity of Joseph. Of the total salts in these samples, 65 per cent was bicarbonate. Both seepage waters and well waters of this vicinity are charged with a high percentage of the bicarbonates.

Three weeks later, June 23, the water from the Sevier Valley canal

was again tested and was found to contain 38 parts, against 16 parts the first time. On the same date the water from the Richfield Canal, which is taken from the river at about the same point as the Brooklyn, was tested and was found to contain 49 parts of salts, against 32 parts in the first instance for the Brooklyn.

One month later, July 23, the water of the Richfield Canal was again tested, and was found to contain 57 parts of salts. Although the total salt content had been steadily increasing, there was at this date no carbonate. This was about the last of the water from Otter Creek reservoir, and it was much colored by the presence of moss which had been broken up in the passage of the water down the stony river bed. It is probable that the decomposing moss gave rise to carbon dioxide, which converted the carbonates to bicarbonates.

The canals in this vicinity, namely, the Sevier Valley, Elsinore, Richfield, Joseph, South Bend, Monroe, Brooklyn, and Annabella, appropriate all of the water of the Sevier River during the irrigation season except in times of flood. Three or 4 second-feet, however, are carried through the Annabella Canal and returned to the river farther down where the Vermilion Canal takes up the seepage accumulated below this point.

The Monroe Canyon furnishes water both for irrigation and domestic purposes for the town of Monroe and for some farming lands to the south. The water is exceptionally good, and when tested in June contained only 14 parts of salts, of which three-fourths were bicarbonate. Several miles south of Monroe is a smaller stream which irrigates several farms in the vicinity. The water from this stream contained 16 parts of salts, of which 82 per cent was bicarbonate.

A large spring just southwest of the town of Richfield is the first and only source of irrigation water thus far encountered on the west side of the valley. This spring issues from a limestone crevice in the base of the mountains and furnishes the water supply which irrigates the land around Richfield. The volume of water is 8 or 10 second-feet, and the area that it irrigates is probably not less than 1,000 acres. It has a temperature of 72°, and the small irrigation streams from it run through the town all winter without freezing. Its salt content is 56 parts, of which 80 per cent is bicarbonate.

At Glenwood two large springs rise in the foothills southeast of the town, and at a height approximately 300 feet above the town. They unite and form a stream of considerable size, which furnishes the water supply of the town and irrigates all of the adjacent farms. The water is colder than that from near Richfield and contains less salts. By means of a pipe line enough power could be cheaply generated to furnish light and power for the town of Glenwood, and yet in no way impair the water supply for irrigating purposes.

At the mountain point between Glenwood and Richfield are several large springs which unite and give rise to Cove Creek, which flows

northward and empties into the Sevier River. An attempt has been made to so dam these springs that they would irrigate the land immediately adjacent, but without success. The aggregate volume of water is about 40 second-feet. It empties into the Sevier River and is taken out at Rockyford by the Rockyford Canal, which irrigates the land west of Salina.

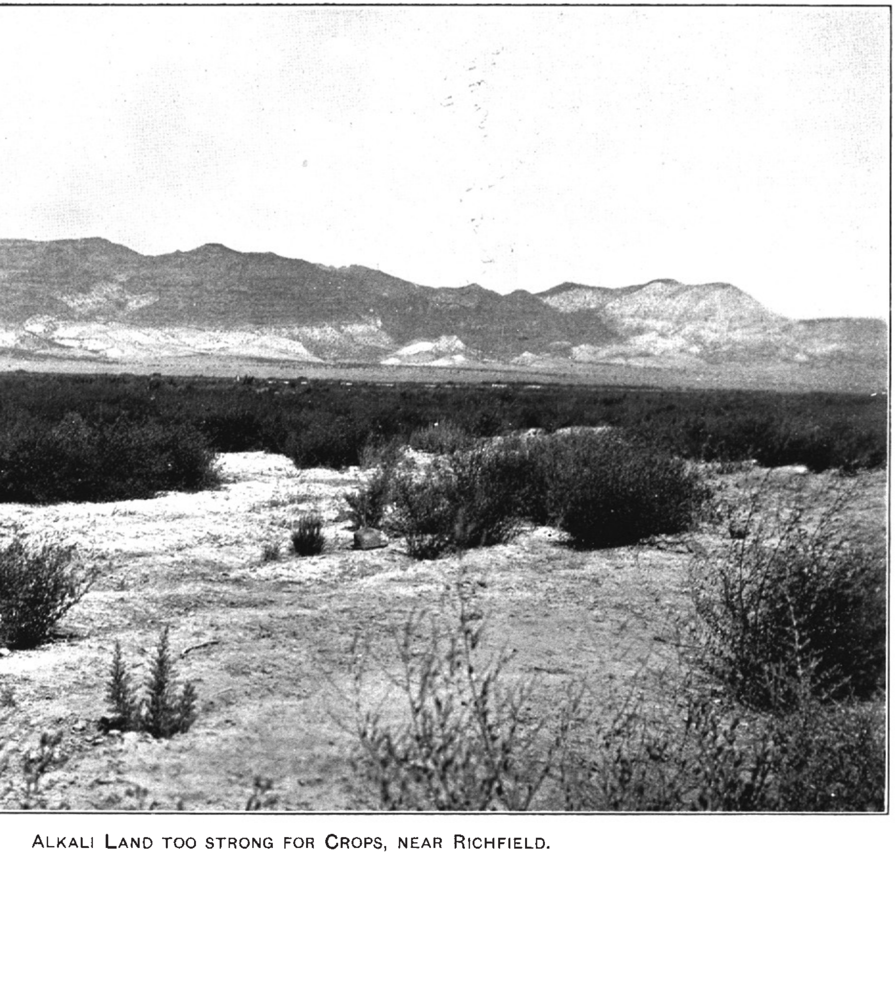
These spring waters are of excellent quality for irrigating purposes and vary but slightly in their character. The water from Cove Creek, which was found to contain 42 parts of salts, represents a little more than the average salt content of the springs, since a small amount of seepage from the Glenwood district joins this creek.

East of Richfield the Vermilion Canal is taken from the Sevier River and furnishes water for irrigating a narrow belt along the river as far north as Salina. The water supply is chiefly seepage, supplemented by 3 or 4 second-feet brought through the Annabella Canal and returned to the river at a short distance above where the Vermilion Canal is taken out. A cross section of this canal would show it to be large, but it has a comparatively small carrying capacity, owing to its slight fall. In July the water was found to contain 77 parts of salts, only a trace being carbonates and 40 per cent being bicarbonates. During 1900 the supply of water for this canal was entirely inadequate to irrigate the land under it, and many of the fields received only one irrigation during the whole season. The head of this canal is in the vicinity where large flows of artesian waters are obtained at a depth of 100 feet or less. Wells flowing one-third of a second-foot can be cheaply obtained, and a number of such wells along the line of the canal would very materially increase its water supply.

Below the intake of the Vermilion Canal a small amount of seepage continues to enter the river channel; several miles farther on this is supplemented by a large volume of spring water entering through Cove Creek. Other springs enter farther on, and the whole volume is taken out at Rockyford Canal, which irrigates a narrow belt of land adjacent to the river, extending northward beyond the town of Redmond. In 1900 this canal had the best water supply in the valley, the volume being constant and continuous throughout the season. An examination of this water in July showed it to contain 74 parts of salts, of which about 40 per cent was bicarbonates.

Beyond the intake of the Rockyford Canal the character or type of alkali changes and the chlorides in both soil and water become first in quantity, while the sulphates are usually second in amount.

Lost Creek is a small tributary which enters the Sevier River 4 or 5 miles south of Salina. Its water is used for irrigating quite a number of farms, but when examined in July it was found to contain 367 parts of salts, of which more than four-fifths were chlorides. Water of such concentration can be used only with great risk, and in a very few years will probably so charge the soils with salts as to make them



Alkali Land too strong for Crops, near Richfield.

unfit for cultivation. This determination was of course made when the volume of water was very low and consequently very salty. When the volume is much larger the salts are of course less in amount, and the accumulation of salts in the soil can then be washed out by the better class of water.

Surface wells in the vicinity showed a salt content of from 200 to 400 parts, of which sodium chloride was also first in amount. The source of these salts is undoubtedly the extensive beds of rock salt found in the mountains just east. These salt beds are usually covered with a layer of salty red-colored soil and the salts are slowly carried to the lower lands by rains.

At Salina the irrigation water is from Salina Creek, which furnishes water for the town and adjacent country. The water supply contained only 100 parts of salt, of which bicarbonates were first in amount. In the soils below the town the chlorides are the chief salts and, indeed, beds of rock salt lie adjacent to the town. The water, unlike the other water examined, carries a high percentage of fine sand and silt which increases its value, for the sand and silt not only fertilize the land but also give to it a surface coating which makes it easy to cultivate and which also serves as a mulch.

The seepage water in the river channel west of Salina was found to contain 328 parts of salts, of which three-fourths were chlorides. A few miles north of Salina the volume of this water becomes sufficient for irrigation and another canal is taken out. Such water, however, can be used only with great risk, and in the course of a few years will load the soils with salts to such an extent as to prevent the profitable growth of crops.

At Redmond there are large springs which give rise to a small lake of the same name. By artificial means the lake has been somewhat enlarged and is used for a storage reservoir. When examined in July, the water, as taken from the lake by an irrigation canal, contained 65 parts of salts, of which 8 per cent was carbonate and 46 per cent bicarbonate. The carbonates have probably been formed from the bicarbonates by the loss of carbon dioxide while standing in the lake.

The next stream of sufficient size to irrigate from is Willow Creek, which enters the valley from the east side. This irrigates only a few farms in the immediate vicinity, and, like most of the small streams, gives an inadequate supply late in the season. The water is good, containing, when low, 104 parts of salts, and the farms irrigated by it bear evidence of successful cultivation.

The next canal, the Kearns & Robbins, is one of considerable size, and is taken directly from the Sevier River. Its water supply is mostly seepage, which accumulates in the river channel from Salina northward; in August it was found to contain 303 parts of salts, of which chlorides and sulphates were the chief constituents. Much of the land under this canal in its virgin state was very salty, and it has

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taken several years of irrigation with this class of water to bring the land into condition for growing alfalfa. Where irrigation water is used freely on greasewood land this vegetation disappears and salt grass takes its place. The land is then used for pasturage or meadow for a few years, after which, if irrigation waters have been used liberally, the land can be broken up and seeded to oats or barley and subsequently to alfalfa. The water usually contains less salts than the 303 parts found in August, as mentioned above, and in a measure corrects the land for the large amount of salts put on by the water when in the condition shown by the above determination.

The West View Canal, taken out on the west side of the Sevier River below the Kearns & Robbins, is the last canal taken out in this area. For this reason its water supply is very poor. The condition of the farms under this canal show that farming here is a struggle against adverse conditions.

The towns of Gunnison and Centerfield, and a large body of land in their vicinity, get their water supply from the San Pitch River and its tributaries. On the river just below Manti is a large reservoir for storing water for this district. When in August this part of the valley was surveyed, the reservoir was dry and the normal flow in the river was very low and contained 182 parts of salts. The flow in Twelvemile Creek, which joins the San Pitch River about 3½ miles east of Gunnison, was also low and carried 117 parts of salts. In Twelvemile Creek the chlorides predominate, while in the San Pitch River chlorides, sulphates, and bicarbonates are found in about equal quantity.

The water supply from this source irrigates a large area of land in this part of the valley, but does not furnish sufficient water for all the good land. There are good sites for more reservoirs, however, and by utilizing them, all of the land north of Willow Creek west to the Sevier River could be irrigated.

The water from a large number of surface wells scattered throughout the district was examined and showed that commonly surface well waters are very salty, the amount of salts varying from 60 to 400 parts. The character of these salts usually corresponds with the salts of the soils in the same vicinity. In the upper part of the valley, about Joseph, Monroe, Elsinore, Richfield, and Glenwood, bicarbonates are first in amount in well waters, while about Lost Creek and Salina the chlorides are much greater than all the other salts combined. At Gunnison and Centerfield the wells invariably show a high percentage of salts, of which sulphates form the greater part. Usually the higher the total salts the smaller the relative amounts of bicarbonates. Normal carbonates are never present in well, spring, or artesian waters, but any of these, upon standing for some time in ponds, reservoirs, or canals, may show carbonates. This change is probably brought about by the loss of carbon dioxide from the water.

The following tables give the field determinations of the salts in a large number of samples of water from canals, springs, wells, artesian wells, and seepage from all parts of the district. The total salts were determined by the electrolytic method; the carbonates and bicarbonates were determined by titrating with tenth normal acid potassium sulphate in the presence of phenolphthalein first and then of methylorange; the chlorides were determined by titrating with tenth normal silver nitrate in the presence of potassium chromate, and the sulphates were determined by difference. It will suffice to say that these analyses represent the condition at the time the survey was made—June to August, inclusive. This represents the important part of the irrigation season, but it is recognized that the year was one of unusual drought, and as a consequence the determinations of the salt content of the waters are probably generally slightly above the normal. When the water supply is most abundant, the percentage of salts is generally lowest, the percentage increasing as the water supply diminishes.

Salts in 100,000 parts of water, as determined in the field, Sevier Valley.

Field No.	Source of water, location, and date of determination.	Carbonates.	Bicarbonates.	Chlorides.	Sulphates.	Total.
	Water from canals.					
34	Sevier Valley Canal, June 4, 1900	0.8	6.8	3.5	4.5	15.6
29	South Bend Canal, June 1, 1900	1.9	6.0	4.6	4.4	16.9
30	Monroe Canal, June 1, 1900	.5	7.9	3.5	5.2	17.1
58	Annabella Canal, June 6, 1900	4.2	19.9	7.1	.0	31.2
36	Brooklyn Canal, June 4, 1900	Tr.	21.2	9.0	2.3	32.5
175	Sevier Valley Canal, June 23, 1900	2.1	26.7	5.8	4.0	38.6
174	Richfield Canal, June 23, 1900	1.0	30.7	5.8	11.6	48.8
368	Richfield Canal, July 23, 1900	.0	34.0	11.6	11.3	57.4
358	Rockyford Canal, July 20, 1900	2.6	29.0	27.8	15.0	74.4
275	Vermilion Canal, July 7, 1900	Tr.	34.0	18.6	24.4	77.0
431	Kearns & Robbins Canal, August 7, 1900	2.1	16.6	194.9	89.4	303.0
434	Gunnison Canal, August 14, 1900	Tr.	63.1	85.8	50.2	199.1
	Mean	1.3	24.7	31.5	18.6	76.0
	Spring waters.					
266	Glenwood Springs		18.3	1.7	.1	20.1
235	Point of mountain west of Glenwood		25.7	5.8	2.4	33.9
335	Butte south of Vermilion		26.6	7.0	3.9	37.5
272	Point of mountains west of Glenwood (east side)		28.2	7.5	4.2	39.9
196	Richfield Spring		46.5	4.6	4.5	55.6
414	Redmond Springs	5.3	30.7	24.4	4.2	64.6
171	Monroe Hot Springs	5.3	53.1	119.5	89.9	267.7
	Mean	1.5	36.4	24.4	15.6	74.2
	Streams.					
86	Monroe Canyon, June 11, 1900	Tr.	10.8	1.2	2.3	14.3
108	Small stream south of Monroe	1.0	14.9	2.3		18.2
259	Cove Creek, July 6, 1900	3.2	26.6	10.4	2.3	42.5
372	Salina Creek, July 23, 1900	2.1	40.7	33.6	12.6	99.0

Salts in 100,000 parts of water, as determined in the field, Sevier Valley—Cont'd.

Field No.	Source of water, location, and date of determination.	Carbonates.	Bicarbonates.	Chlorides.	Sulphates.	Total.
	Streams—Continued.					
409	Willow Creek, July 23, 1900	5.3	43.2	36.0	19.9	104.4
449	Sterling coal mine, August 22, 1900	0.0	50.5	3.5	10.4	64.4
450	Sixmile Creek, August 22, 1900	3.7	32.5	1.2	2.2	39.6
437	Twelvemile Creek, August 14, 1900	.8	47.3	34.8	33.7	116.6
436	San Pitch River, August 14, 1900	3.7	54.4	95.1	31.2	182.4
389	Lost Creek, July 30, 1900	3.2	13.3	298.1	52.6	367.2
352	Small stream south of Vermilion	Tr.	37.3	1,097.2	22.5	1,156.0
	Mean	2.1	33.8	146.7	17.3	200.0
	Artesian wells.					
277	Bolithos, 95 feet deep, 2 miles E. of Richfield		33.2	5.2	5.1	43.5
276	Bolithos, 82 feet deep, 2 miles E. of Richfield		31.5	9.3	9.1	49.9
316	Pump well, sec. 16, T. 23 S., R. 2 W		44.8	4.6	1.5	50.9
280	Segmiller well, 2½ miles E. of Richfield		29.0	17.4	10.6	57.2
267	Glenwood, 69 feet deep		56.4	9.3	4.8	70.5
251	Sec. 29, T. 23 S., R. 2 W		59.8	10.4	8.1	78.4
242	Sec. 31, T. 24 S., R. 2 W		27.4	44.1	20.3	91.8
	Mean		40.3	14.3	8.5	63.1
	Driven wells.					
391	Sec. 9, T. 22 S., R. 1 W		24.9	116.0	82.1	223.0
74	Sec. 23, T. 24 S., R. 3 W., 50 feet		88.0	32.5	129.0	249.6
392	Across road from 391, 85 feet		49.8	183.3	182.0	415.0
	Mean		54.2	110.6	131.0	295.8
	Surface wells.					
103	Sec. 12, T. 25 S., near river, 6 feet to water		42.3	5.8	8.8	56.9
43	Sec. 14, T. 25 S., R. 4 W., 30 feet to water		30.7	5.8	24.1	60.6
56	Sec. 34, T. 24 S., R. 3 W., 22 feet to water		55.6	9.3	11.2	76.1
182	Sec. 18, T. 24 S., R. 2 W., 8 feet to water		68.9	10.4	16.0	97.3
369	White house well, Salina		93.8	13.9		100.4
166	Sec. 13, T. 24 S., R. 3 W		85.5	30.2	38.1	153.8
429	Sec. 29, T. 19 S., R. 1 E., 31 feet to water		78.8	63.7	49.5	195.6
425	Sec. 20, T. 19 S., R. 1 E., 20 feet to water		97.9	75.4	44.7	218.0
421	Christensen house, 12 feet to water		93.8	58.0	82.0	233.8
433	Robbins ranch		90.5	80.0	74.5	245.0
93	Sec. 1, T. 25 S., R. 4 W		45.6	161.2	90.0	296.7
445	Sec. 4, T. 20 S., R. 1 E, 65 feet to water		36.5	134.5	208.7	379.7
200	Sec. 12, T. 24 S., R. 3 W		72.2	150.8	261.1	484.1
	Mean		68.6	61.5	69.7	199.8
	Seepage.					
33	Near river, 2 miles SW. of Elsinore		24.6	30.2	28.5	83.3
136	Near river at Annabella		70.0	12.0	12.0	94.0
379	Sevier River at Salina		17.8	238.9	70.9	327.6
458	Drainage from Robbins ranch	4.2	17.0	232.0	97.0	350.2
	Mean	1.0	32.4	128.3	52.1	213.8

Sevier Valley irrigation waters.

COMPOSITION.

[Parts in 100,000 parts of water.]

Constituent.	Sevier Valley Canal at Elsinore, June 23.	Richfield Canal at Elsinore, June 23.	Rocky-ford Canal at Salina, July.	Gunnison Canal east of Gunnison, August.	Monroe Hot Springs, Monroe, June 23.	Seepage at river near Central, June 19.
Ca	6.4	7.6	6.4	6.5	29.7	7.1
Mg	1.3	2.0	2.9	8.9	3.9	4.9
Na	2.9	4.0	10.1	13.5	54.6	9.2
K	1.1	0.9	2.1	4.6	5.1	0.9
SO_4	5.9	7.2	11.6	35.6	93.2	11.1
Cl	3.5	7.0	16.9	15.5	66.7	7.0
CO_3	2.7	3.0	0.0	0.0	2.7	5.1
HCO_3	16.6	20.0	20.3	35.7	24.8	36.1
Total	40.4	51.7	70.3	120.3	280.7	81.4

THEORETICAL PERCENTAGE COMBINATION.

$CaSO_4$	20.54	19.62	23.32	18.38	35.93	19.29
$MgSO_4$				20.78	6.88	
Na_2SO_4					3.46	
CaCl			6.26			
MgCl			16.07	12.63		
KCl	5.20	3.27	5.69	7.31	3.46	2.09
NaCl	10.15	19.62	8.82		36.49	12.53
$Ca(HCO_3)_2$	40.10	35.76				12.41
$Mg(HCO_3)$	2.97	13.65				21.37
$NaHCO_3$	11.63		39.84	40.90	12.14	23.59
$MgCO_3$	9.41	8.08				8.72
Na_2CO_3					1.64	

Water containing less than 150 parts of salts can be used with safety for irrigating purposes, except when the salts are largely sodium carbonate. When more than 150 parts of salts are present, care should be exercised in the management and application of the water. Three hundred parts of salts may be taken as the extreme limit for irrigation purposes, above which it is never safe to go except in cases of emergency on good lands, where one or two applications of salty water may be used if good water can afterwards be obtained to wash the salts out or down. With a salt content of from 250 to 300 parts the best results can never be obtained, and great danger accompanies the constant use of this class of water.

Of the various salts usually present in either soil or irrigation water the carbonates and chlorides are the most harmful, while the sulphates and bicarbonates are least so. The lime sulphate, especially when sodium carbonate is present in the soil, is beneficial; in limited amounts it is also helpful in the presence of the chlorides. In the former case the sodium carbonate is partly converted to sodium sulphate, with the resulting calcium carbonate, which is so slightly

soluble as to be harmless. In the case of chlorides, sodium chloride is converted in part into calcium chloride, which is less harmful than the former, and which, in small amounts, has a stimulating effect upon plants.

APPLICATION OF WATER.

Water in Sevier County being scarce, the farmers irrigate their fields by the furrow method, which consists in running parallel furrows from 3 to 4 inches in depth at intervals of from 2 to 2½ feet down the slope of the field and then turning the water into these furrows. This has two chief advantages over the flooding system, namely, greater economy of water and the doing away of the necessity of leveling of fields. In the case of alkali soils, or when the irrigation water carries much salts, the flooding method is better. Furrow irrigation leaves the salts on the ridges and its accumulation is often sufficient to do much damage. Flooding washes the whole surface and carries the salts down, and when the water goes sufficiently deep they pass beyond the zone of active root growth and do no harm. Successful irrigation by flooding requires level fields, and level fields for grain and alfalfa are preferable, as they are much easier to harvest and also insure a better distribution of water to the small plants.

In the application of water, especially on loose, sandy soils and on sandy loams where the underlying stratum is of the same or perhaps even more porous character, great care should be exercised not to run water over fields for too long a distance. When this is done a great loss of water often occurs, for the water sinks into the ground so rapidly that the portion of the field nearest the ditch is often overirrigated before the water reaches the lower part of the field. For the most economical use of water the land should be well leveled and a good-sized volume of water used for irrigating. The distance over which to run water should be short, so that the whole of the area can be quickly covered and thus give all parts as nearly as possible an equal time in which to become wet. Too much water is harmful, not only to the area to which it is applied, but often to lands at a lower level. Lowlands may be, and often are, ruined for all agricultural purposes by the accumulation of alkali and seepage water caused by the overirrigation of lands at higher levels.

How much water to apply at an irrigation and how frequently to irrigate are problems which have not been thoroughly investigated. Obviously, both of these questions will depend upon a number of factors; for example, the kind of soil, the character and stage of growth of the crop, and the climatic conditions of rainfall and rate of evaporation. So long as water does not pass beyond the roots of the crops and become lost to them, heavy irrigation, with long intervals between, is the most economical of water. Frequent irrigation with

small amounts of water is wasteful because of the relatively larger amount of water which evaporates directly from the ground surface. Shallow irrigation is also conducive to shallow root growth, which condition does not allow the plants to withstand drought.

A large number of observations in a great many States and on all types of soil has brought out the fact that when the most favorable moisture content for plant growth is diminished by 25 per cent the soil becomes too dry, and when increased by the same amount it is too wet, for the most favorable results. This, therefore, gives us a basis on which to estimate the amount of water required for an irrigation.

A medium sandy loam, having about 12 per cent of clay, will contain under the most favorable condition about 16 per cent of its dry weight of moisture. When this amount of moisture is decreased by 25 per cent, that is, when it falls to 12 per cent of the dry weight of the soil, then drought begins and the soil needs irrigation. When the normal moisture is increased by 25 per cent, that is, raised to 20 per cent of the dry weight of the soil, irrigation should cease, for beyond this amount the soil becomes too wet for favorable plant growth. In case of a medium sandy loam, therefore, we have a range of 8 per cent in moisture, extending from 12 to 20 per cent of the dry weight of the soil, in which the moisture conditions are favorable to plant growth and above and below which they become unfavorable. When the lower limit is reached, irrigation should begin and be continued until the upper limit is reached; in other words, the soil moisture should be increased 8 per cent. Assuming that the soil needs irrigating to a depth of 4 feet and that a cubic foot of dry sandy loam weighs 85 pounds, it would require $4 \times 85 \times 0.08$, or 27.2 pounds of water to each square foot of surface. This is equal to an irrigation of $5\frac{1}{4}$ inches of water over the entire surface of the field. Allowing three-fourths of an inch for loss by evaporation from the water during irrigation and from the excessive wet surface for a short time thereafter, it seems quite safe to say that under the above conditions 6 inches of water would be required at an irrigation. No rule can be given as to how frequently such an irrigation should be repeated, because so much depends upon the climatic conditions, the kind of crop, and its stage of growth. In order to apply the usual amount of water estimated for a season's irrigation, that is, $2\frac{1}{2}$ feet of water, such irrigation in order to cover a period of four months should be made at intervals of twenty-four days.

The loss of water by evaporation and seepage during its transit through canals, laterals, and ditches to the land to be irrigated is in many cases enormous, and every means not entailing undue expense should be resorted to in order to reduce this loss to a minimum. Many cases are reported where only one-fourth of the supply from streams ever reaches the land to be irrigated. In the older and more

valuable irrigated districts water-tight pipe lines or cement ditches are used, at considerable expense, to conduct the water to the lands. The value of water will necessarily increase in the Sevier Valley and more expensive and better means must be used for its conservation.

In the construction of canals the chief point to guard against is loss by seepage. When run over sandy or gravelly soils the loss of water from this source is often enormous. If the water to be used is at times laden with silt, the leaky canals may soon become lined with fine material and thus stop the leakage, but if clear water only is used the leaks may continue for an indefinite time. Canals when built on this character of soil should be well puddled, a good way of puddling being to drive a flock of sheep or goats through the canals while they are wet.

Level canals, having a slow water movement, often become filled to such an extent with growing moss as to nearly stop the flow of water. In cases of this kind the moss should be removed, and there are two ways in which this can be readily accomplished—either by letting all the water out of the canal for a day or two when there is bright sunshine, thus killing the moss, which will cause no trouble when the water is turned in again, or by running a disk harrow the length of the ditch. This disk harrow agitates the mud, entangles it with the moss, and on settling it carries the moss to the bottom of the canal, where it does no harm.

ALKALI.

In most Western soils there is a sufficient amount and often a superfluity of soluble salts. Indeed, some of the soils in the Sevier Valley are entirely crusted with salts, which must be washed out before crops can be grown. The usual forms of alkali are the chlorides, sulphates, carbonates, and bicarbonates, especially the latter. The chlorides are more in evidence in the lower part of the valley than in the upper part, owing to the very large amount of rock salt (halite) found near Salina and Redmond. Chlorine is not found to a large extent in the artesian wells nor in the canals, so it has undoubtedly come from the mountains, where sodium chloride exists in beds formed from the early salt waters. The normal carbonates are not present in large quantites, but, on the contrary, the bicarbonates are found everywhere, usually in abundance.

The action of bicarbonates on plants is being examined in the Division of Soils at present and will be made the subject of an extended report. It is quite likely they are not so harmful as many of the other forms of white alkali; nevertheless, as will be shown, their presence is obnoxious.

Mr. Lyman J. Briggs, of the Division, has shown that soil has the power of absorbing and retaining a much larger proportion of carbon dioxide than there is present in the air. The action of carbon dioxide in water on magnesium and calcium carbonates.($MgCO_3$ and $CaCO_3$)

in Grainfield which has been reclaimed from Alkali through ordinary Irrigation.

easy feel and water does not enter it readily to leach out the alkali, but simply flows over the surface.

partially dissolves those minerals with the formation of their bicarbonates, as $Ca(HCO_3)_2$. But these salts dissociating, the HCO_3 group will react with the common salt ($NaCl$) and sodium sulphate (Na_2SO_4), forming bicarbonate of sodium ($NaHCO_3$).

The foregoing reactions may be thus expressed:

$$CaCO_3+CO_2+H_2O=Ca(HCO_3)_2$$
$$Ca(HCO_3)_2+Na_2SO_4\leftrightarrow CaSO_4+\underline{NaHCO_3}$$
$$Ca(HCO_3)_2+2NaCl\leftrightarrow CaCl_2+\underline{NaHCO_3}$$

The latter product (sodium bicarbonate) is the salt so abundant in the waters and soils in the Sevier Valley, and being quite soluble, is carried everywhere by the water. When the water stands exposed to the air, as, for example, when standing on the surface of the ground around artesian wells or on the ground after irrigation or in ditches, etc., the pressure of the carbonic acid in the air being less, the bicarbonate breaks up to some extent, giving off carbonic acid, the following reaction takes place to a certain extent:

$$2NaHCO_3=\underline{Na_2CO_3}+CO_2+H_2O$$

The underscored is the black alkali, or sodium carbonate. This result can be seen on the banks of almost any ditch or canal in Sevier Valley, around the artesian wells, and around pools of water standing in the road. The water itself may have no normal carbonate when applied, but a black surface is formed on the soil after the water has stood, due to the change above noted.

There is a large amount of gypsum ($CaSO_4$) present in the soil, which under favorable conditions, according to the following equation, would change to a great extent the black alkali to the white, a less dangerous form of alkali:

$$CaSO_4+Na_2CO_3\rightleftarrows CaCO_3+Na_2SO_4$$

But the existing conditions will not permit a complete change to take place, and even if it went on very rapidly there is constantly a large reserve of bicarbonates being continuously drawn upon to form more black alkali. As these irrigation waters and artesian wells all contain bicarbonates, it is obvious that water must be applied to the soil with judgment, or the alkali conditions will gradually become worse.

The alkali maps show the condition of the whole district as regards the percentage of soluble salts present in the upper 5 feet of soil when at water saturation. These maps should be of great value to the landowners of the district and also to prospective settlers in showing just what lands are sufficiently free from alkali to be cultivated with safety, the lands that have only moderate amounts of alkali and require great care in cultivation, and the lands undoubtedly too salty to produce crops until the salts have in part seen removed.

All areas showing less than 0.2 per cent of salts may be considered safe for all kinds of farm crops, and there will never be any danger from alkali so long as good water is used and the land is well drained. In case of poor drainage, the water table rising within 3 feet or less of the surface, there may be a sufficient accumulation of the salts at the immediate surface to kill crops and yet the percentage in the upper 5 feet not exceed 0.2 per cent.

The areas having from 0.2 to 0.4 per cent are, with few exceptions, risky to cultivate, and under the most favorable conditions the fields of grain and alfalfa invariably show spots where the crops either fail entirely or make only a feeble growth. It must of course be borne in mind that when near the lower limit of this range the conditions may be quite good if the salts are well distributed or are mostly in the lower depths. On the other hand, if the upper limit is approached and the salts are massed at the surface the conditions may be such as to entirely prevent the growth of crops. When the average salt content is above 0.4 per cent the lands are never safe to cultivate in any of our ordinary farm crops. With from 0.4 to 0.6 per cent sweet clover may be grown which will produce a large growth of forage of rather poor character, but if harvested very early it will produce fairly good fodder for cattle. The growth shades the ground surface and the roots add organic matter and nitrogen to the soil, all of which tend to lessen the deleterious effects of the alkali, although it may not actually reduce the percentage of salts present.

A summing up of the alkali map shows that 100,900 acres, or 72.9 per cent of the area surveyed, have less than 0.2 per cent of salts and are perfectly safe to cultivate. In the upper portion of the valley about Joseph, Monroe, and Elsinore practically all of the land falls in this class. Here the water is of excellent quality, the drainage is good, and a larger percentage of the land is under cultivation than elsewhere in the valley.

The following table shows the acres and percentage of the land variously affected by alkali:

Salt content, per cent.	Areas in acres.	Percentage of whole area.
.0-0.2	100,900	72.9
.2-0.4	11,800	8.5
.4-0.6	13,000	9.4
.6-1	10,700	7.7
1.0-3	2,100	1.5

As a rule, the alkali lands occur in the lower and more level portions of the valley, where the drainage is poor and where the soils are more apt to be of a heavy texture. In the virgin state, dry lands with good drainage invariably show an increase in salt content as the depth

increases, while the reverse is true if the lands are wet and subject to excessive evaporation. In a general way this also applies to cultivated lands.

KINDS OF ALKALI.

The following table shows the percentage composition of 13 crusts collected from various parts of the district:

Chemical composition of salts in crusts and soils.

No.	Description.	Per cent soluble.	Ca.	Mg.	Na.	K.	SO_4.	Cl.	CO_3.	HCO_3.
		P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4716	White alkali crust near Warm Springs, Joseph	18.63	3.08	0.18	31.34	1.40	32.23	31.25	0.03	0.39
4717	White alkali crust, 1¼ miles SW. of Richfield	24.87	1.74	6.26	22.71	.41	44.81	22.86	......	1.21
4718	White alkali crust, 1¼ miles SE. of Richfield	21.51	2.19	6.28	22.94	.34	38.91	28.78	......	.56
4719	Crust from Hot Springs at Monroe	37.33	1.78	.48	30.04	1.88	50.91	14.33	.39	.19
4721	Crust from edge of furrow at Central	2.01	3.98	.60	22.97	6.36	12.23	23.76	......	30.11
4722	White alkali crust, 1¼ miles NE. of Monroe	5.27	2.62	.42	27.88	1.44	54.20	2.66	1.82	8.96
4723	White alkali crust	3.03	5.55	Tr.	24.58	3.24	35.02	8.13	5.28	18.17
4724	Black alkali crust, one-fourth mile N. of SE. C. sec. 3, T. 24 S., R. 3 W.	5.04	1.55	.32	31.28	2.86	17.68	33.46	.36	12.49
4725	Alkali crust from nook along river, Elsinore	36.99	.05	Tr.	36.82	1.10	15.85	44.72	.81	.65
4890	Crust, C. of SE. ¼ sec. 2, T. 24 S., R. 3 W.	24.85	1.96	1.96	29.66	.70	37.21	27.29	......	1.22
4909	Crust, W. C. sec. 10, T. 23 S., R. 2 W., largely chlorides	5.89	9.34	7.71	15.05	1.77	5.27	58.28	......	2.58
4920	Brown crust, ¼ W. of N. C. sec. 29, T. 23 S., R. 2 W	14.98	13.52	3.43	18.04	.71	5.61	57.48	......	1.21
4951	Crust, 0 to one-half inch	50.97	1.68	2.86	29.98	.67	25.48	39.03	......	.30
	Mean	......	3.72	2.35	26.41	1.76	28.88	30.16	.67	6.00

The above table shows the bases and acids as actually determined, and the following table gives the theoretical combination of these bases and acids:

Theoretical percentage combination.

No.	Description.	$CaSO_4$.	$MgSO_4$.	Na_2SO_4.	K_2SO_4.	$CaCl_2$.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
4716	White alkali crust near Warm Springs, Joseph	10.46	0.90	35.71	......	......
4717	White alkali crust, 1¼ miles SW. of Richfield	5.91	31.00	23.53	......	......
4718	White alkali crust, 1¼ miles SE. of Richfield	7.46	31.10	13.05	......	......
4719	Crust from Hot Springs at Monroe	6.08	2.37	66.19	......	......
4721	Crust from edge of furrow at Central	13.52	3.27	......	......	......
4722	White alkali crust, 1¼ miles NE. of Monroe	8.89	2.05	68.51	......	......
4723	White alkali crust	18.84	......	32.11	......	......
4724	Black alkali crust, one-fourth mile N. of SE. C. sec. 3, T. 24 S., R. 3 W	5.27	1.55	18.95	......	......
4725	Alkali crust from nook along river, Elsinore	.18	......	23.26	......	......
4890	Crust, C. of SE. ¼ sec. 2, T. 24 S., R. 3 W	6.63	9.77	35.34	1.55	......
4909	Crust, W. C. sec. 10, T. 23 S., R. 2 W., largely chlorides	7.44	......	......	......	19.80
4920	Brown crust, ¼ W. of N. C. sec. 29, T. 23 S., R. 2 W.	7.94	......	......	......	30.92
4951	Crust, 0 to one-half inch	5.69	14.16	13.84	1.49	......
	Mean	8.06	7.40	25.42	.23	3.90

Theoretical percentage combination—Continued.

No.	Description.	$MgCl_2$.	NaCl.	KCl.	Na_2CO_3.	$NaHCO_3$.
4716	White alkali crust near Warm Springs, Joseph	....	49.51	2.65	0.23	0.54
4717	White alkali crust, 1½ miles SW. of Richfield	....	37.11	.78	....	1.67
4718	White alkali crust, 1½ miles SE. of Richfield	....	46.99	.64	....	.76
4719	Crust from Hot Springs at Monroe	....	20.84	3.58	.68	.26
4721	Crust from edge of furrow at Central	....	29.62	12.14	....	41.45
4722	White alkali crust, 1½ miles NE. of Monroe	....	2.24	2.73	3.23	12.35
4723	White alkali crust	....	8.59	6.15	9.32	24.99
4724	Black alkali crust, one-fourth mile N. of SE. C. sec. 3, T. 24 S., R. 3 W	....	50.95	5.43	.63	17.22
4725	Alkali crust from nook along river, Elsinore	....	72.15	2.10	1.42	.89
4890	Crust, C. of SE. ¼ sec. 2, T. 24 S., R. 3 W	....	45.04	....	....	1.67
4909	Crust, W. C. sec. 10, T. 23 S., R. 2 W., largely chlorides	30.23	35.66	3.30	....	3.57
4920	Brown crust, ¼ W. of N. C. sec. 29, T. 23 S., R. 2 W	13.45	44.67	1.35	....	1.67
4951	Crust, 0 to one-half inch	....	64.41	....	....	.41
	Mean	3.36	39.06	3.14	1.19	8.27

All of these samples showed carbonates when tested in the field, but the laboratory examination shows only six out of the thirteen to contain carbonates. By comparing the percentage of the crust that went into solution, when 50 grams were placed in a liter of water, with the column giving the percentage of bicarbonates, we find that the latter are very much higher where the crusts were not concentrated, and that where the crusts went largely into solution the bicarbonates comprise only a small percentage of the total salts. This was noticeable throughout the field determinations of the district. Wherever salts of either soils or waters were present in small or only moderate amounts bicarbonates were first in amount, but when the alkali conditions became bad the relative amount of the bicarbonates became smaller while the chlorides or sulphates increased. Throughout the southern half of the Richfield district bicarbonates predominate and are equal to fully one-half of all the salts present. From Glenwood northward to Redmond chlorides predominate, especially on the east side of the valley, while the sulphates are second in amount. From Redmond northward bicarbonates again become first in amount, except along the lowlands adjacent to the river.

A large number of determinations throughout the district shows black alkali (Na_2CO_3) to be nearly always present, but usually in small amounts. Of a hundred or more determinations only six showed more than 0.1 per cent of black alkali, and in five of these the total salt content was greater than 0.5 per cent. The determination showing black alkali as the source of trouble represents only a small local spot.

Throughout the district, lime and magnesia carbonates are very plentiful and are responsible for the large percentage of bicarbonates that are so frequently present.

The source of the alkali is from the decomposing rocks and from

beds of rock salt that exist in various places along the mountains. There is not sufficient rainfall to carry these salts out of the valley, but they are frequently moved for some distance and massed either in wet, poorly drained areas or in heavy soils.

As a rule, the lands are so well underdrained that when irrigated the salts are gradually carried away and do no harm. From Richfield northward, however, there is considerable lowland bordering on the river in which the drainage is not always good. It is in these soils that the alkali is usually worst, and here also the problem of getting rid of it is most difficult. Where the natural drainage is poor artificial drainage should be resorted to as the means of carrying away the alkali when the land is irrigated.

SEEPAGE.

The seepage waters of the southern half of the district are, as a rule, not heavily charged with salts, but that which finds its way into the river from Salina northward is quite salty. The largest amount of damage done by seepage is in the vicinity of Richfield and Glenwood. The sketch map on page 269 shows 2,500 acres here which have standing water within 3 feet or less of the ground surface, and 10,500 acres in which the water is within from 3 to 6 feet of the surface. In the vicinity of Richfield the Richfield Canal leaks considerably, and there is undoubtedly much seepage from the land irrigated both by this canal and by the two canals which are situated above it. It is from this same source that the lands immediately south of the town are made wet. By far the greater part of the wet land, however, is caused by numerous springs which occur all along the base of the mountains, both north and south of Glenwood. These springs keep the flat land of the vicinity saturated with water and cause an accumulation of salts at the surface. While much of this land is underlaid by a porous sand, which under ordinary circumstances would afford good drainage, yet the land here is so level and the supply of water which causes the damage is so plentiful that the land is always wet. A few large ditches to conduct the water from these springs, instead of allowing it to soak into the adjacent lands, would make a marked change in the condition of this neighborhood.

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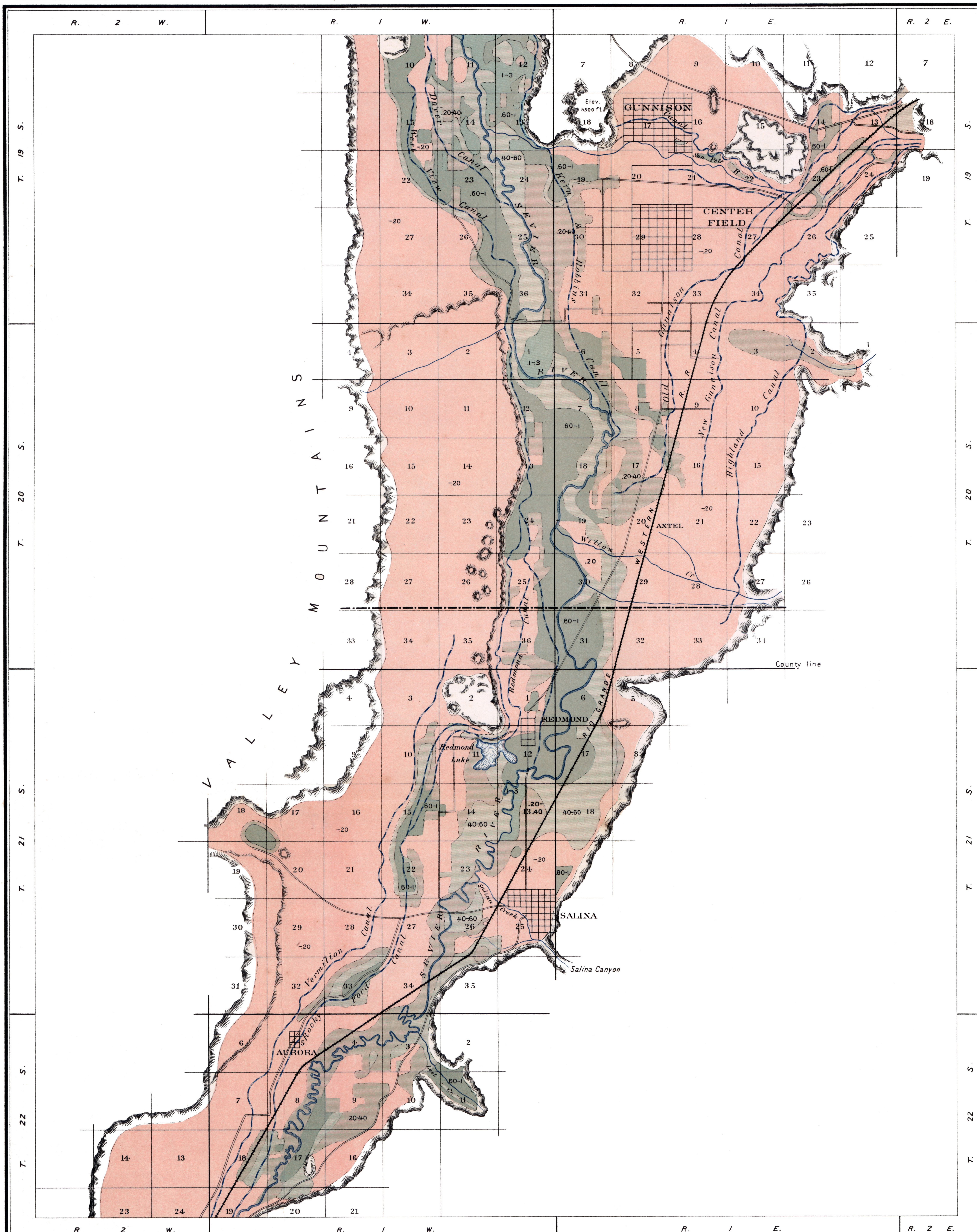
U.S. DEPT. OF AGRICULTURE
DIVISION OF SOILS
MILTON WHITNEY, CHIEF.

ALKALI MAP
UTAH
GUNNISON SHEET

UTAH AGRICULTURAL
EXPERIMENT STATION
LUTHER FOSTER, DIRECTOR



Alkali Surveyed by
Frank D. Gardner and
Chas. A. Jensen
Conditions June to Aug. 1900

Scale 1 in.=1 mile

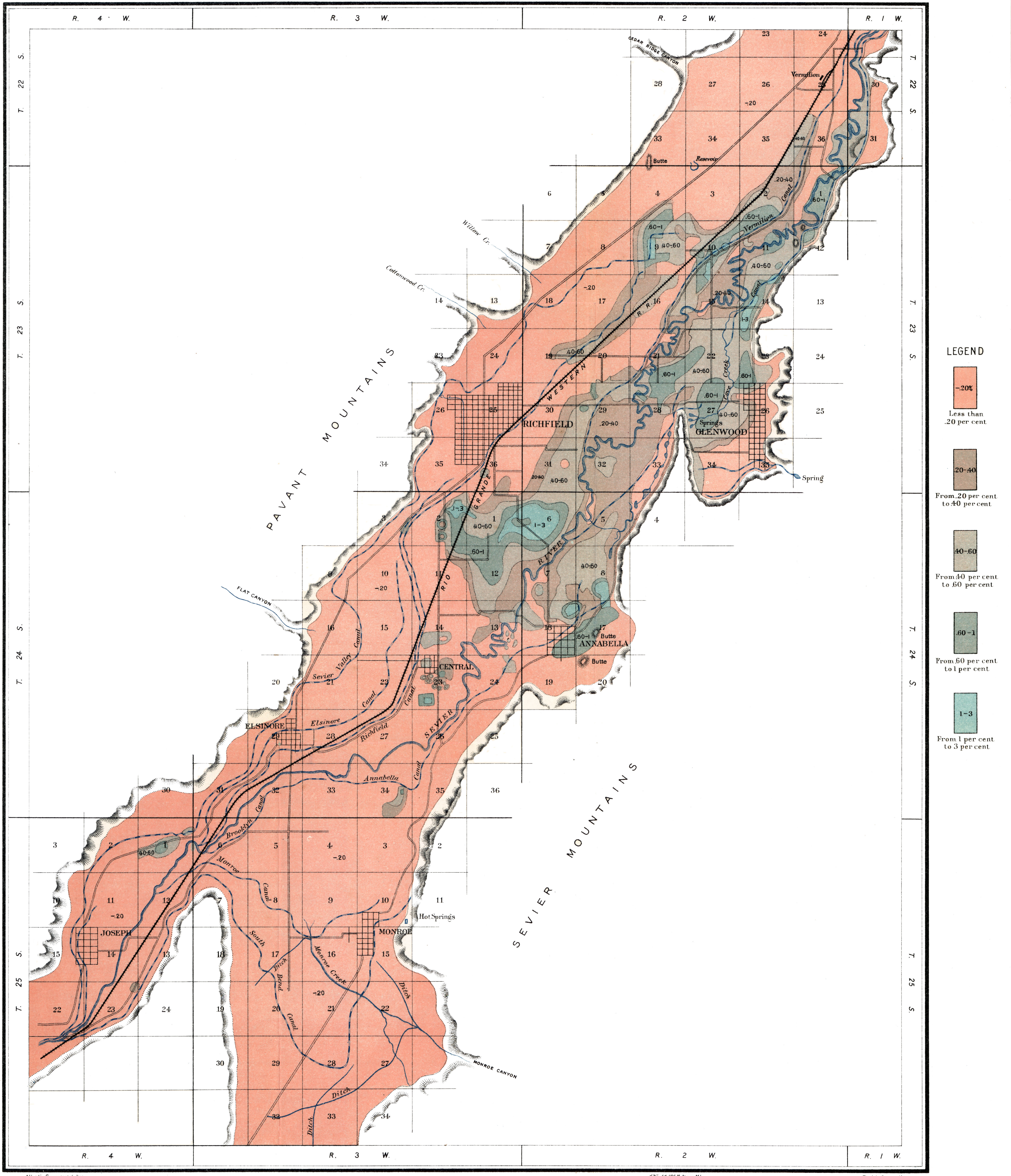
A. Hoen & Co. Lith. Baltimore, Md.

Field Operations
Division of Soils,
1900

U.S. DEPT. OF AGRICULTURE
DIVISION OF SOILS
MILTON WHITNEY, CHIEF.

ALKALI MAP
UTAH
RICHFIELD SHEET

UTAH AGRICULTURAL
EXPERIMENT STATION
LUTHER FOSTER, DIRECTOR



Alkali Surveyed by
Frank D. Gardner and
Chas. A. Jensen
Conditions, June to August 1900

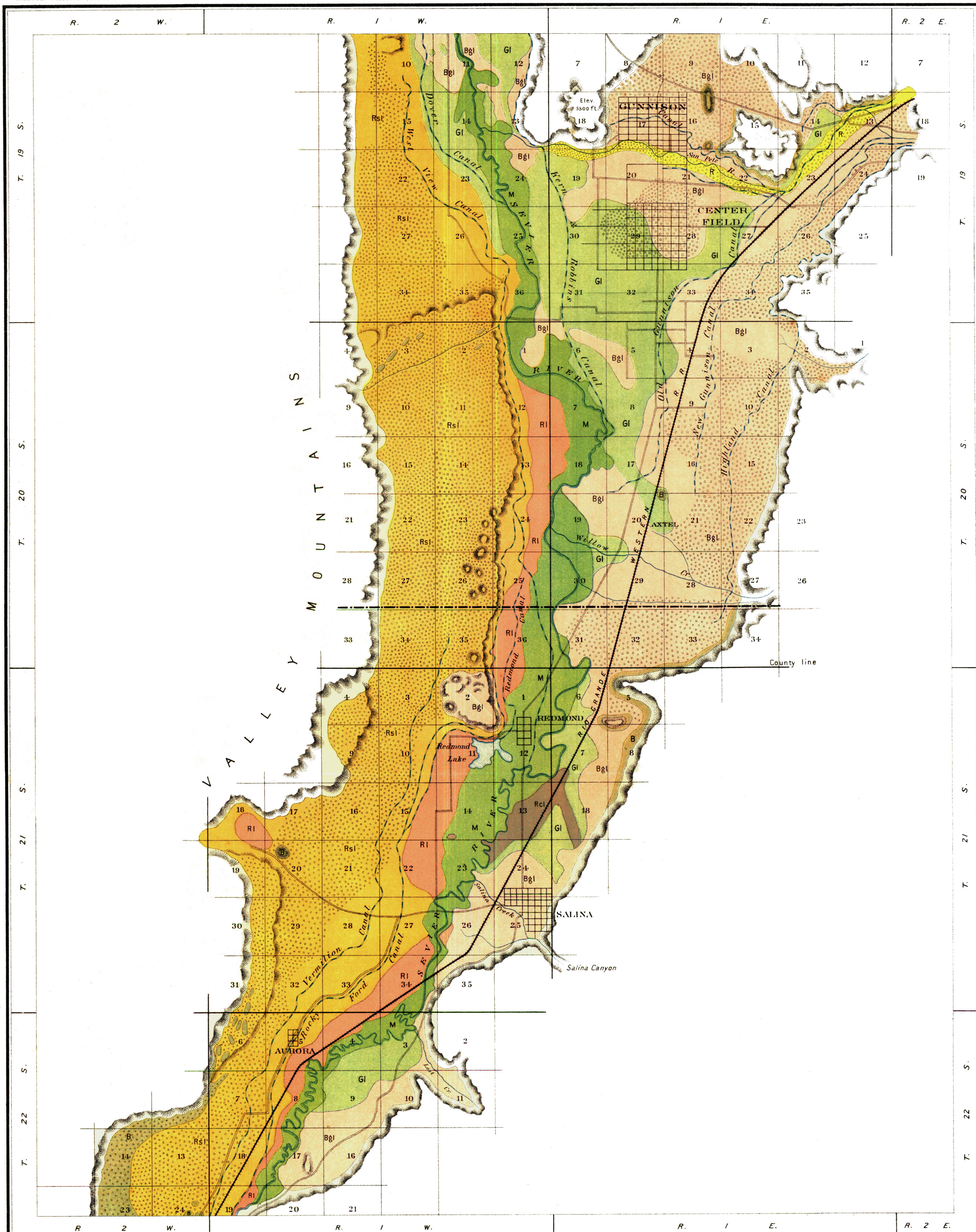
Scale 1 in.=1 mile

Field Operations
Division of Soils
1900

U.S. DEPT OF AGRICULTURE
DIVISION OF SOILS
MILTON WHITNEY, CHIEF.

SOIL MAP
UTAH
GUNNISON SHEET

UTAH AGRICULTURAL
EXPERIMENT STATION
LUTHER FOSTER, DIRECTOR



SOIL PROFILE
(6 feet deep)

Bingham gravelly loam — Ssc; Ssc Gr

Redfield sandy loam — Ssc

Redfield loam — Sc; Ssc

Glenwood loam — Sc; Scc

Redfield clay loam — Scc C; S

Meadow — Ssc

Bingham stony loam — St

River wash — Gr

LEGEND

S — Sand
Sc — Loam
Ssc — Sandy loam
Scc — Clay loam
Ssc Gr — Gravelly loam
Scc C — Clay loam
St — Stony
Gr — Gravel

LEGEND

Bgl — Bingham gravelly loam

Rsl — Redfield sandy loam

Rl — Redfield loam

Gl — Glenwood loam

Rcl — Redfield clay loam

M — Meadow

B — Bingham stony loam

R — River wash

Gravel areas

Soils Surveyed by
Frank D. Gardner and
Chas. A. Jensen
1900

Scale 1 in.=1 mile

A. Hoen & Co. Lith. Baltimore, Md.

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Division of Soils
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U.S. DEPT. OF AGRICULTURE
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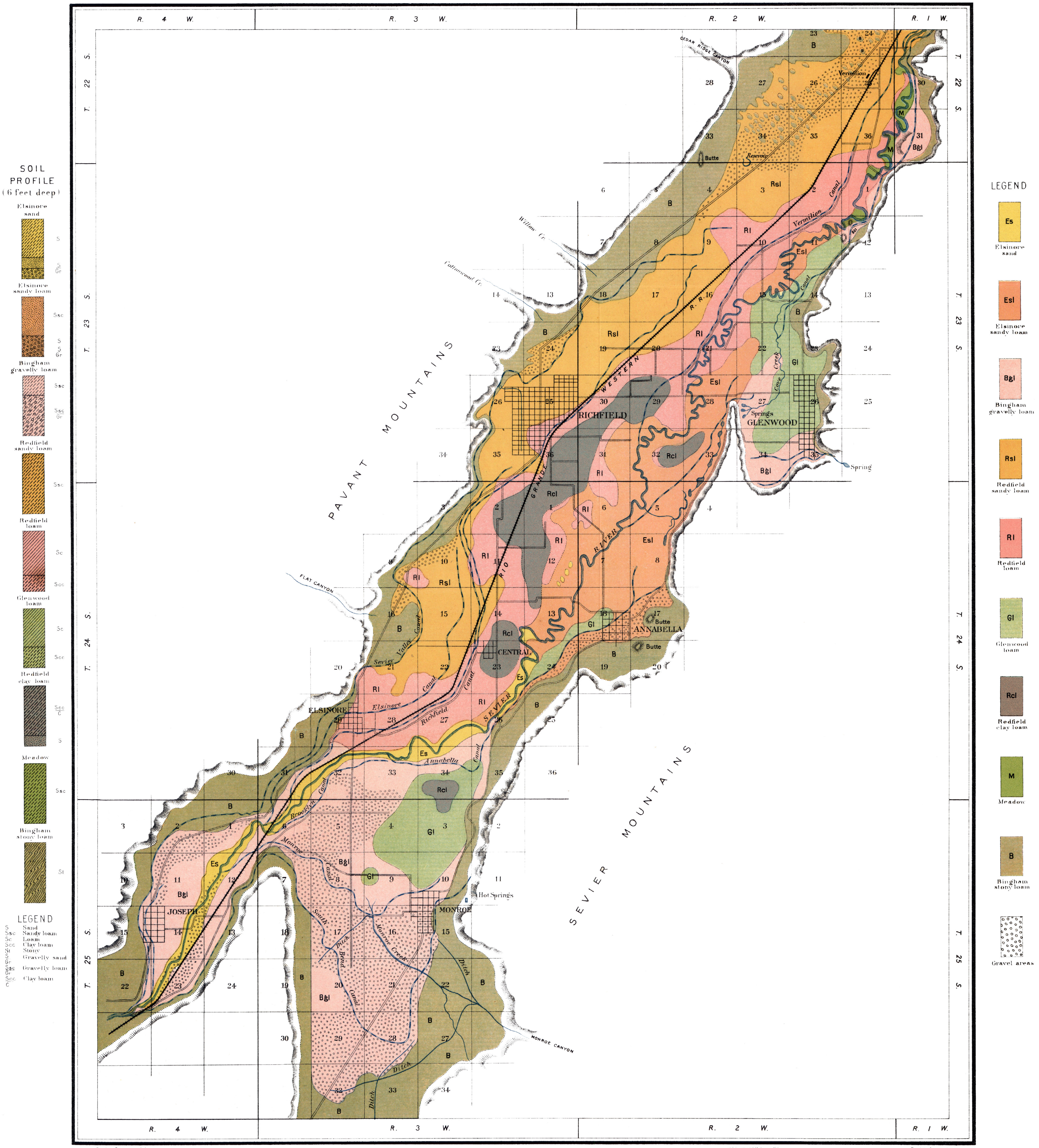
MILTON WHITNEY, CHIEF

SOIL MAP
UTAH
RICHFIELD SHEET

UTAH AGRICULTURAL
EXPERIMENT STATION
LUTHER FOSTER, DIRECTOR



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1900

Scale 1 inch = 1 mile

Field Operations
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1900